PALÆONTOGRAPHICAL SOCIETY.

VOL. XXI.

PLANTS

OF THE

CARBONIFEROUS STRATA.

PART I.

PAGES 1—32; PLATES I—VI.

SUPPLEMENT

TO THE

FOSSIL CORALS.

PART IV, No. 2.

LIASSIC.

PAGES 45—73; PLATES XII—XVII.

CRETACEOUS ECHINODERMATA.

VOL. I, PART II.

PAGES 65—112; PLATES IX, X, XII—XXI, XXIA, XXIB.

FISHES

OF THE

OLD RED SANDSTONE.

PART I.

PAGES 1—33; PLATES I—V.

PLEISTOCENE MAMMALIA.

PART II.

PAGES 29—124; PLATES VI—XIX.

ISSUED FOR 1867.

PALÆONTOGRAPHICAL SOCIETY

VOLUME [illegible]

[illegible]

PALÆONTOGRAPHICAL SOCIETY.

VOLUME XXI.

CONTAINING

THE FLORA OF THE CARBONIFEROUS STRATA. Part I. By Mr. E. W. Binney. Six Plates.

SUPPLEMENT TO THE FOSSIL CORALS. Part IV.—No. 2 (Liassic). By Dr. Duncan. Six Plates.

THE FOSSIL CRETACEOUS ECHINODERMATA. Vol. I.—Part II. By Dr. Wright. Fourteen Plates.

THE FISHES OF THE OLD RED SANDSTONE. Part I. By Messrs. J. Powrie and E. Ray Lankester. Five Plates.

THE PLEISTOCENE MAMMALIA. Part II. By Messrs. Boyd Dawkins and W. A. Sanford. Fourteen Plates.

ISSUED FOR 1867.

JUNE, 1868.

THE PALÆONTOGRAPHICAL SOCIETY was established in the year 1847, for the purpose of figuring and describing the *whole* of the British Fossils.

Each person subscribing ONE GUINEA *is considered a Member of the Society, and is entitled to the Volume issued for the Year to which the Subscription relates.*

Subscriptions are considered to be due on the First of January in each year.

The back volumes are in stock, and can be obtained (one or more) on application to the Treasurer or the Honorary Secretary.

The volumes are delivered free of carriage to any address within three miles of the General Post-Office, and are booked free of expense to any place beyond the three-mile radius; but in that case the carriage must be paid by the Member to whom they are sent.

Gentlemen desirous of forwarding the objects of the Society can be provided with circulars for distribution on application to the Honorary Secretary, the Rev. THOMAS WILTSHIRE, 13, Granville Park, Lewisham, near London, S.E.

The Annual Volumes are now issued in two forms of Binding: 1st, with all the Monographs stitched together and enclosed in one cover; 2nd, with each of the Monographs fastened in a paper cover, and the whole of the separate parts enclosed in an envelope.

Members wishing to obtain the Volume arranged in the latter form are requested to communicate with the Honorary Secretary.

The Volume for 1868 will be issued, in all probability, before the close of the present year.

LIST

OF

The Council, Secretaries, and Members

OF THE

PALÆONTOGRAPHICAL SOCIETY;

AND

A CATALOGUE OF THE WORKS ALREADY PUBLISHED; A CLASSIFIED LIST OF THE MONOGRAPHS COMPLETED AND IN PREPARATION, WITH THE NAMES OF THEIR RESPECTIVE AUTHORS; THE DATES OF ISSUE OF THE ANNUAL VOLUMES; AND A GENERAL SUMMARY SHOWING THE NUMBER OF THEIR PAGES, PLATES, AND FIGURES, AND OF THE SPECIES ILLUSTRATED AND DESCRIBED.

Council and Officers elected 31st March, 1868.

President.

J. S. BOWERBANK, LL.D., F.R.S., G.S.

Vice-Presidents.

T. DAVIDSON, ESQ., F.R.S., G.S.
SIR R. I. MURCHISON, BART., F.R.S., G.S.
PROF. OWEN, M.D., F.R.S., G.S.
PROF. PHILLIPS, F.R.S., G.S.

Council.

PROF. ANSTED, M.A., F.R.S., G.S.
C. DARWIN, ESQ., F.R.S., G.S.
W. BOYD DAWKINS, ESQ., F.R.S., G.S.
P. M. DUNCAN, M.B., F.G.S.
R. ETHERIDGE, ESQ., F.G.S.
R. HUDSON, ESQ., F.R.S., L.S.
J. W. ILOTT, ESQ.
J. GWYN JEFFREYS, ESQ., F.R.S., G.S.
H. LEE, ESQ., F.L.S., G.S.
W. H. LEIGHTON, ESQ., F.G.S.
SIR C. LYELL, BART., M.A., F.R.S., G.S.
J. PICKERING, ESQ.
J. PRESTWICH, ESQ., F.R.S., G.S.
PROF. TENNANT, F.G.S.
C. TYLER, ESQ., F.L.S., G.S.
T. WRIGHT, M.D., F.G.S.

Treasurer.

SEARLES WOOD, ESQ., F.G.S., Brentwood, Essex.

Honorary Secretary.

REV. T. WILTSHIRE, M.A., F.G.S., 13, Granville Park, Lewisham, Kent, S.E.

Local Secretaries.

Alton—WM. CURTIS, JUN., ESQ.
Bath—WM. WALTON, ESQ.
Berlin—MESSRS. FRIEDLÄNDER & SON.
Birmingham—W. MATHEWS, JUN., ESQ., F.G.S., Edgbaston.
Blackburn—W. HARRISON, ESQ., F.G.S.
Blandford—W. SHIPP, ESQ.
Bristol—W. SANDERS, ESQ., F.R.S., G.S.
Cambridge—JAMES CARTER, ESQ.
Cheltenham—T. WRIGHT, M.D., F.G.S.
Cirencester—J. BRAVENDER, ESQ., F.G.S.
Colchester—C. R. BREE, M.D.
Deddington—CHAS. FAULKNER, ESQ., F.S.A., G.S., R.G.S.
Devizes—WM. CUNNINGTON, ESQ., F.G.S.
Dublin—GILBERT SANDERS, ESQ., M.R.I.A.
Edinburgh—PROF. BALFOUR, M.D., F.R.S., L.S.
Guildford—R. A. C. GODWIN-AUSTEN, ESQ., F.R.S., F.G.S., Chilworth.
Kendal—THOMAS GOUGH, ESQ.
Leeds—THOS. NUNNELEY, ESQ.
Leicester—JAMES PLANT, ESQ.
Liverpool—G. H. MORTON, ESQ., F.G.S.
Norfolk—REV. J. GUNN, M.A., F.G.S., Irstead, Norwich.
Oxford—PROF. J. PHILLIPS, F.R.S., G.S.
Paris—M. F. SAVY, 24, Rue Hautefeuille.
Plymouth—J. H. FUGE, ESQ.
Richmond, Yorkshire—EDWARD WOOD, ESQ., F.G.S.
Scarborough—JOHN LECKENBY, ESQ., F.G.S.
Tonbridge Wells—J. SHARP, ESQ., F.G.S.
Torquay—WM. PENGELLY, ESQ., F.R.S., G.S.
Wolverhampton—HY. BECKETT, ESQ., F.G.S.

LIST OF MEMBERS.*

APRIL, 1868.

HER MOST GRACIOUS MAJESTY THE QUEEN.

Adlard, J. E., Esq., Bartholomew Close, E.C.
Aitken, John, Esq., Lane End, Bacup, Manchester.
Allport, S., Esq., Snow Hill, Birmingham.
Angelin, Professor, Stockholm.
Ansted, Professor D. T., M.A., F.R.S., G.S., &c., Athenæum Club; and 33, Brunswick Square.
Arbuthnot, Capt. W., 25, Hyde Park Gardens, W.
Asher and Co., Messrs., 13, Bedford Street, Covent Garden, W.C.
Athenæum Library, Liverpool.
Auerbach, Professor, Moscow.
Austen, Rev. J. H., M.A., Ensbury House, Wimborne.
Austin, Miss Helena E., 19, Henrietta Street, Bath.
Aveline, W. T., Esq., F.G.S., Museum of Practical Geology, Jermyn Street.

Backhouse, Edward, Esq., Ashburne House, Sunderland.
Balfour, Professor, M.D., F.R.S., L.S., &c., *Local Secretary*, 27, Inverleith Row, Edinburgh.
Balme, E. B. Wheatley, Esq., Cotewall, Mirfield, Normanton, Yorkshire.
Barclay, Joseph G., Esq., 54, Lombard Street, E.C.
Barlow, H. C., M.D., F.G.S., 11, Church Yard Row, Newington Butts, Surrey, S.
Barr, W. R., Esq., Park Mills, Stockport.
Barthes and Lowell, Messrs., 14, Great Marlborough Street, W.
Bath Royal Literary and Scientific Institution.
Bathurst, Rev. W. H., Lydney Park, Gloucester.
Battersby, R., M.D., Torquay.
Beaufoy, George, Esq. (Executors of the late), South Lambeth, S.
Beaumont, Rev. W. J., M.A., Trinity College, Cambridge.
Becker, M. Edvald, Breslau, Silesia.
Beckett, Henry, Esq. F.G.S., *Local Secretary*, Darlington Street, Wolverhampton.
Bell, Professor T., F.R.S., L.S., G.S., &c., The Wakes, Selborne, Alton, Hants.
Benson, Starling, Esq., F.G.S., Swansea.

* The Members are requested to inform the Secretary of any errors or omissions in this list, and of any delay in the transmission of the Yearly Volumes.

Bernard, Ralph M., Esq., 5, Victoria Square, Clifton.
Bewley, John, Esq., 4, Brown's Buildings, Liverpool.
Bigsby, J. J., M.D., F.G.S., 89, Gloucester Place, Portman Square, W.
Bilke, Edward, Esq., F.G.S., &c., 12, Stamford Street, S.
Binney, E. W., Esq., F.R.S., G.S., &c., 40, Cross Street, Manchester.
Birmingham Free Library, Radcliffe Place, Birmingham.
Birmingham Old Library, Union Street, Birmingham.
Blackburne, John George, Esq., F.G.S., Oldham.
Blackie, W. G., Esq., Ph.D., F.G.S., &c., 36, Frederick Street, Glasgow.
Blackmore, Humphrey P., M.D., Salisbury.
Bladon, James, Esq., Pontypool.
Blake, W., Esq., Bridge House, South Petherton.
Blanford, H. F., Esq., F.G.S., 21, Bouverie Street, Whitefriars, E.C.
Boase, H. S., M.D., F.R.S., G.S., &c., Claverhouse, near Dundee.
Bohn, Henry, Esq., 4, York Street, Covent Garden, W.C.
Bonney, Rev. George, F.G.S., St. John's College, Cambridge.
Bordeaux, La Faculté des Sciences de.
Borradaile, Charles, Esq., East Hothly, Hurst Green, Sussex.
Bosquet, Mons. J., For. Cor. G.S., Pharmacien, Maestricht.
Boston Society of Natural History, Boston, U.S.A.
Bower, Rev. E., Closworth, near Yeovil.
Bowerbank, J. S., LL.D., F.R.S., &c., *President*, 2, East Ascent, St. Leonard's-on-Sea.
Bowles, Rev. S. J., Balton's-borough, Glastonbury.
Bradford Philosophical Society, Duke Street, Bradford.
Brady, Antonio, Esq., F.G.S., Stratford, Essex; and Admiralty Office, Somerset House, W.C.
Brady, Right Hon. M., Dublin.
Braikenridge, Rev. G. W., M.A., F.S.A., G.S., &c., Clevedon, near Bristol.
Brassey, Thomas, Esq., jun., 56, Lowndes Square, S.W.
Bravender, John, Esq., F.G.S., *Local Secretary*, Coxwell Street, Cirencester.
Bree, C. R., M.D., *Local Secretary*, East Hill, Colchester.
Briggs, General John, F.R.S., G.S., &c., Oriental Club, Hanover Square, W.; and Bridge Lodge, Hurstpierpont.
Briggs, Miss Ellen, 3, Arlington Street, S.W.
Brighton and Sussex Natural History Society, 7, Pavilion Parade, Brighton.
British Museum, Printed Book Department, W.C.
British Museum, Departmental Mineralogical and Geological Library, W.C.
Broome, C. E., Esq., M.A., &c., Elmhurst, Batheaston, Bath.
Brown, Edwin, Esq., F.R.G.S., G.S., Burton-on-Trent.
Brown, Isaac, Esq., Ackworth, Pontifract.
Brown, T. C., Esq., Cirencester.
Browne, Wm. Meredith, Esq., Westminster Fire Office, King Street, Covent Garden, W.C.
Buckman, Professor James, F.G.S., &c., Bradford Abbas, Sherborne, Dorset.
Busk, George, Esq., F.R.S., L.S., &c., 32, Harley Street, Cavendish Square, W.
Byerley, Isaac, Esq., Seacombe, Cheshire.

Cambridge University Library.
Carpenter, Alfred, M.D., Croydon, S.
Carpenter, W. B., M.D., F.R.S., &c., 56, Regent's Park Road, N.W.

Carter, James, Esq., *Local Secretary*, 30, Petty Cury, Cambridge.
Cassini, H. T., Esq., Victoria Cottage, Archway Road, Highgate, N.
Cavell, Edmund, Esq., F.G.S., Saxmundham.
Chamberlin, Rev. T., C.B.
Chambers, Robert, Esq., F.R.S.E., G.S., &c., St. Andrew's.
Champernowne, Arthur, Esq., Darlington Hall, Totness, Devonshire.
Chapman, Thomas, Esq., 23, New Street, Spring Gardens, S.W.
Cheltenham Permanent Library, 18, Clarence Street, Cheltenham.
Cherbullier, Mons., Paris.
Christ's College, Cambridge, Library of.
Clabon, J. M., Esq., 21, Great George Street, S.W.
Clark, Dr. W., F.R.S., &c., Cambridge.
Clarke, Rev. W. B., F.G.S., &c., St. Leonards, near Sydney, New South Wales.
Clayton, Rev. J. H., Liphook, Hants.
Cobbold, Rev. R. H., Rectory, Broseley, Salop.
Cocchi, Sig. Q., Professor of Geology, Florence.
Colchester, W., Esq., F.G.S., Grundesburgh Hall, Ipswich.
Collings, Rev. W. T., M.A., F.L.S., G.S., Lord of Sark, Channel Islands.
Collingwood, F. J. W., Esq., Glanton Pyke, Glanton, Northumberland.
Colvin, Col. John, C.B., Leintwardine, near Ludlow.
Compton, Rev. John, Minesteed Parsonage, Lyndhurst.
Cooke, Lieut.-Col. A. C., R.E., 95, Mount Street, W.
Cooper, Charles J., Esq., Bridgenorth, Salop.
Cornthwaite, Rev. T. M., M.A., Walthamstow.
Cotteau, Mons., Paris.
Cotton, R. P., M.D., F.G.S., 46, Clarges Street, Piccadilly, W.
Cranage, Dr. J. E., The Old Hall, Wellington, Shropshire.
Crickitt, E., Esq., 12, Catherine Place, Bath.
Cross, Rev. J. E., Appleby Vicarage, Brigg, Lincolnshire.
Cross, R. A., Esq., Hill Cliff, Warrington.
Crowley, Alfred, Esq., Bramley Oaks, Croydon, S.
Cubitt, George, Esq., M.P., F.G.S., 17, Princes Gate, W.
Cull, R., Esq., 13, Tavistock Street, Bedford Square, W.C.
Cunnington, W., Esq., F.G.S., *Local Secretary*, Devizes, Wilts.
Curtis, W., Esq., *Local Secretary*, Alton, Hants.
Currey, Elliot S., Esq., Erlwood, Bagshot.
Cust, Lady Elizabeth, 13, Eccleston Square, S.W.

Darlington Naturalists' Society.
Darwin, Charles, Esq., M.A., F.R.S., G.S., &c., Down, Bromley, Kent.
Davidson, Thomas, Esq., F.R.S., G.S., Mem. Geol. Soc. France, &c., *Vice-President*, 33, Park Crescent, Brighton.
Daw, E., Esq. (Rev. A. Foster, Little Munden Rectory, Ware).
Dawkins, W. Boyd, Esq., F.R.S., G.S., Museum of Practical Geology, Jermyn Street, S.W.
Dawson, Principal J. W., LL.D., F.R.S., G.S., &c., McGill's University, Montreal.
Day, Rev. Hen. Geo., M.A., Sedbergh, Kendal.
Deane, H., Esq., F.L.S., Clapham Common, Surrey, S.
De Castro, James C., Esq., 21, Neville Street, Onslow Square, W.C.

Denison, Col. Sir William, R.E., K.C.B., F.R.S., R.A.S., East Brent, Weston-super-Mare, Somersetshire.

Deshayes, Mons. G. P., F.M.G.S., Paris.

Devonshire, Duke of, Chancellor of the University of London, F.R.S., G.S., &c., Devonshire House, Piccadilly, W.

Devon and Exeter Institution, Exeter (by Ed. Parfitt, Esq.)

Dewilde, G. R., Esq., 14, Peak Hill Avenue, Sydenham.

Dickinson, F. H., Esq., King Weston, Somerton.

Dickinson, Henry, Esq., Severn House, Coalbrook Dale.

Dickinson, W., Esq., Thorncroft, Workington.

Dickinson, W., Esq., 5, St. Mildred's Court, E.C.

Digby, Lady, Minterne, near Dorchester.

Dilke, Sir C. Wentworth, Bart., F.G.S., L.S., &c., 76, Sloane Street, S.W.

Dollfus, Mons., Paris.

Dorset County Museum Library, Dorchester.

Douglas, Rev. Robert, Trent Valley House, Lichfield.

Dover Proprietary Library.

Doyen, Mons. J. M.

Ducie, the Earl of, F.R.S., G.S., &c., 1, Belgrave Square, S.W.

Dudley and Midland Geological and Scientific Society and Field-Club.

Dumortier, Mons. E., Lyons (by Mons. F. Savy, Paris).

Duncan, P. M., M.B., F.G.S., 48, Lee Terrace, Lee, S.E.

Durham, the Dean and Chapter of, Durham (by Samuel Rowlandson, Esq., the College, Durham).

Eassie, W., Esq., F.G.S., 11, Park Road, Regent's Park, N.W.

Eccles, James, Esq., Springwell House, Blackburn.

Edgell, Rev. E. Wyatt, 2, Lansdowne Terrace, Ladbroke Square, Notting Hill, W.

Edinburgh Geological Society, Edinburgh.

Edinburgh Museum of Science and Art, Argyle Square, Edinburgh.

Edwards, F. E., Esq., F.G.S., 22, Woburn Square, W.C.

Egerton, Sir Philip de Malpas Grey, Bart., M.P., Trustee Brit. Museum, F.R.S., G.S., &c., Oulton Park, Cheshire; and 28B, Albemarle Street, W.

Elliott, John, Esq., Kingsbridge, Devon.

Elliot, Sir Walter, K.S.I., F.L.S., Wolfelee, Hawick, N.B.

Enniskillen, William Willoughby, Earl of, D.C.L., F.R.S., G.S., &c., Florence Court, Enniskillen; and Athenæum Club, S.W.

Eskrigge, R. A., Esq., 3, Batavia Buildings, Liverpool.

Etheridge, R., Esq., F.G.S., &c., Museum of Practical Geology, Jermyn Street, S.W.

Evans, John, Esq., F.R.S., G.S., Nash Mills, Hemel Hempstead.

Evans, Thomas, M.D., Gloucester.

Everest, Rev. R., F.G.S., 50, Cleveland Square, W.

Eyton, Thomas C., Esq., F.L.S., G.S., &c., Eyton, near Wellington, Salop.

Falconer, Thomas, Esq., F.G.S., Usk, Monmouthshire.

Falkner, Frederick, Esq., Somersetshire Bank, Bath.

Farnham, Lord, Carlton Club, 94, Pall Mall, S.W.

Faulkner, Charles, Esq., F.S.A., G.S., R.G.S., *Local Secretary*, Museum, Deddington, Oxon.

Favre, Mons. Alph., Professor of Geology, Academy, Geneva.
Ferguson, William, Esq., F.L.S., G.S., R.G.S., &c., Kinmundy, Mintlaw, Aberdeenshire; and 2, St. Aidan's Terrace, Birkenhead.
Fielding, Edward, Esq., 142, St. Paul's Road, Camden Square, N.W.
Fisher, Rev. Osmond, M.A., F.G.S., Elmstead Vicarage, Colchester.
Fletcher, T. W., Esq., M.A., F.R.S., G.S., S.A., Lawneswood House, Stourbridge.
Flower, J. W., Esq., F.G.S., Park Hill, Croydon, S.
Forbes, John Edward, F.G.S., 3, Faulkner Street, Manchester.
Fort, Richard, Esq., F.G.S., 24, Queen's Gate Gardens, Kensington, W.
Fox, Rev. W. Darwin, Delamere Rectory, near Chester.
Fraser, John, M.D., Wolverhampton.
Friedländer, Messrs., *Local Secretaries*, Berlin.
Froggat, John, Esq., Church Gate, Stockport.
Fryer, A., Esq., Chatteris, Cambridgeshire.
Fuge, J. H., Esq., F.R.C.S.E., 16, Frankfort Street, Plymouth.

Galton, Captain Douglas, R.E., F.R.S., G.S., &c., 12, Chester Street, Grosvenor Place, S.W.
Gardner, J. S., Esq., F.G.S., Park House, St. John's Wood Park, N.W.
Gassiot, I. P., Esq., F.R.S., &c., Clapham, S.
Gatty, Charles, Esq., F.G.S., Felbridge Park, East Grinstead.
Geological and Polytechnic Society of the West Riding of Yorkshire, Leeds.
Geological Society of Manchester.
Geological Survey of Great Britain, Palæontological Department, Jermyn Street, S.W.
Geologists' Association, King's College, W.C.
Gibson, G. S., Esq., Saffron Walden.
Gibson, Thomas F., Esq., F.G.S., &c., Broadwater Down, Tunbridge Wells.
Gilbertson, Henry, Esq., Hertford.
Gilchrist, J., M.D., Crichton Royal Institution, Dumfries.
Glasgow Geological Society, Andersonian University, Glasgow.
Gloucester Literary Society, Gloucester (by Dr. B. Wagbourn).
Godlee, Burwood, Esq., Leighside, Lewes.
Godlee, Rickman, Esq., Lillies, Upton, Essex.
Godwin-Austen, R. A. C., Esq., F.R.S., G.S., &c., *Local Secretary*, Chilworth Manor, Guildford, Surrey.
Gordon, P. L., Esq., Craigmyle.
Gough, Capt. the Hon. George S., F.G.S., L.S., &c., Lough Cutra Castle, Gort, Galway, Ireland.
Gough, Thomas, Esq., *Local Secretary*, Kendall.
Gould, John, Esq., F.R.S., L.S., Z.S., &c., 26, Charlotte Street, Bedford Square, W.C.
Gratton, Joseph, Esq., 32, Gower Street, W.C.
Gray, John, Esq., Lyttleton Terrace, Hagley, near Stourbridge.
Gregory, J. R., Esq., 15, Russell Street, Covent Garden, W.C.
Griffith, Sir Richard, Bart., LL.D., F.R.S.E., G.S., &c., 2, Fitzwilliam Place, Dublin.
Grundy, Thomas, Esq., Beatlands, Sidmouth, Devon.
Guise, Sir W. V., Bart., F.G.S., &c., Elmore Court, near Gloucester.
Gunn, Rev. J., M.A., *Local Secretary*, Irstead Rectory, Norwich.
Guppy, R. Lechmere, Esq., F.G.S., Government House, Trinidad.

Hall, Hugh F., Esq., F.G.S., 17, Dale Street, Liverpool.
Hall, Townshend M., Esq., F.G.S., Pilton Parsonage, Barnstaple.
Hanson, Samuel, Esq., 47, Botolph Lane, E.C.; and 43, Upper Harley Street, W.
Harford, Frederick, Esq., Ocean Marine Insurance Company, 2, Old Broad Street, E.C.
Harkness, Professor Robert, F.R.S., G.S., Queen's College, Cork.
Harris, W., Esq., F.G.S., Charing, Ashford, Kent.
Harrison, William, Esq., F.G.S., S.A., R.G.S., R.S. Ant., &c., *Local Secretary*, Samlesbury Hall, Blackburn, Lancaster; and Conservative Club, St. James's Street, S.W.
Hartley Institution, Southampton (by Dr. F. T. Bond).
Haughton, Rev. Professor S., M.D., F.R.S., G.S., Fellow of Trinity College, Dublin.
Hawkes, Rev. Henry, B.A., F.L.S., &c., 5, Elm Grove, Southsea, Portsmouth.
Hawkins, B. Waterhouse, Esq., F.L.S., G.S., Belvedere Road, Upper Norwood, S.
Hawkshaw, J. Clarke, Esq., Beverley, Yorkshire.
Haythornthwaite, William, Esq., Kirkby Lonsdale.
Heywood, James, Esq., F.R.S., G.S., &c., Athenæum Club, S.W.
Hicks, Henry, Esq., St. David's, Pembrokeshire.
Higgins, E. T., Esq., 9, Richmond Crescent, Barnsbury, N.
Hindson, Isaac, Esq., Kirkby Lonsdale.
Hirst, John, jun., Esq., Dobcross, Saddleworth, near Manchester.
Hodgson, Miss E., Cavendish Street, Ulverstone.
Holden, Adam, Esq., 48, Church Street, Liverpool.
Homfray, D., Esq., F.G.S., Portmadoc, Carnarvonshire.
Hony, Rev. W. E., F.G.S., &c., Archdeacon of Sarum, Beverstock, near Salisbury.
Hopgood, James, Esq., Clapham Common, S.
Horen, Dr. F. Van, St. Trond, Belgium.
Horner, Rev. John S., Mells Park, near Frome.
Howard, Mrs., Greystoke Castle, Penrith.
Howitt, Thomas, Esq., Queen Square, Lancaster.
Huddersfield Literary and Scientific Society.
Hughes, T. M'K., Esq., B.A., F.G.S., Museum of Practical Geology, Jermyn Street, S.W.
Hudson, Robert, Esq., F.R.S., G.S., Clapham, S.
Hull, W. D., Esq., F.G.S., &c., Maison Cormalde, Nice.
Hunter, J. R. S., Esq., Braidwood, Carluke, N.B.
Hutton, R., Esq., F.G.S., M.R.I.A., &c., Putney Park, S.W.
Huxley, Professor T. H., LL.D., Ph.D., F.R.S., L.S., G.S., Museum of Practical Geology, Jermyn Street, S.W.

Illingworth, Rev. E. A., 3, Mecklenburgh Street, W.C.
Illingworth, R. S., Esq., 9, Norfolk Crescent, W.
Ilott, James William, Esq., Bromley, Kent.
Ipswich Museum, Ipswich.

J'Anson, E., Esq., 7A, Laurence Pountney Hill, E.C.
James, Colonel Sir H., R.E., F.R.S., G.S., &c., Ordnance Survey, Southampton.
Jarvis, Richard H., Esq., F.G.S., Beckenham, Kent, S.E.
Jeffreys, J. Gwyn, Esq., F.R.S., L.S., G.S., 25, Devonshire Place, Portland Place, W.
Johnes, J., Esq., F.G.S., Dolancothy, Llandilo, Wales.

Johnson, William, Esq., Eton College.
Jukes, J. Beete, Esq., M.A., F.R.S., F.G.S., &c., Geological Survey of Ireland, 51, Stephen's Green, Dublin.
Judd, J. W., Esq., F.G.S., Museum of Practical Geology, Jermyn Street, S.W.

Kenyon, Robert, Esq., 6, Lower Berkeley Street, Portman Square, W.
Kenyon, the Hon. Mrs. Thomas, Pradoe, near Shrewsbury.
King, W. P., Esq., Avonside, Clifton Down, Bristol.
Kinnaird, Lord, Rossie Priory, Inchture, N.B.
Kingston, G. S., Esq., Grote Street, Adelaide, South Australia.
Knight, Captain E., 15, Elvaston Place, South Kensington, W.
Krantz, Herr, Bonn.

Lawrance, John, Esq., F.G.S., Elton, Oundle.
Leckenby, John, Esq., F.G.S., *Local Secretary*, Scarborough.
Lee, Henry, Esq., F.L.S., G.S., The Waldrons, Croydon, S.
Lee, John Edward, Esq., F.G.S., The Priory, Caerleon, Monmouthshire.
Leeds Library, Leeds, Yorkshire.
Leicester Literary and Philosophical Society, Town Museum, Leicester.
Leighton, W. H., Esq., 2, Merton Place, Turnham Green, W.
Leonard, Edward J., Esq., Engineer's Office, West India Docks, E.
Lightbody, Robert, Esq., Ludlow.
Lindsay, Charles, Esq. (by W. Stuart, Esq., Walbrook Buildings, Walbrook, E.C.)
Lingard, John R., Esq., 4, Westminster Chambers, S.W.
Linnean Society, Burlington House, Piccadilly, W.
Lister, J. J., Esq., F.R.S., &c., Upton, Essex.
Literary and Philosophical Society of Manchester.
Literary and Philosophical Society of Newcastle.
Literary and Philosophical Society of Sheffield (by J. Holland, Esq., Music Hall, Sheffield).
Liveing, Professor G. D., M.A., St. John's College, Cambridge.
Liverpool Free Public Library.
Liverpool Natural History Society.
Lloyd, John, Esq., 77, Snow Hill, E.C.
Lloyd, J. H., Esq., 10, Lancaster Gate, W.
London Institution, Finsbury Circus, E.C.
Lovèn, Professor S., Stockholm.
Lubbock, Sir John W., Bart., M.A., F.R.S., L.S., 15, Lombard Street, E.C.
Lucas, Joseph, jun., Esq., Upper Tooting, Surrey.
Lucas, John F., Esq., Middleton, Yolgrave, Bakewell, Derbyshire.
Ludlow Natural History Society.
Lyall, George, Esq., F.G.S., 38, Winchester Street, South Shields.
Lyell, Sir C., Bart., M.A., F.R.S., L.S., G.S., &c., 72, Harley Street, Cavendish Square, W.
Lyon, Bibliothèque de la Ville de.

McAndrew, R., Esq., F.R.S., Bond Street Chambers, Walbrook, E.C.
Mackeson, Henry B., Esq., F.G.S., &c., Hythe, Kent.

Mackey, Colonel, Fairhill, near Exeter.
Maclean, William C., Esq., 5, Camperdown Terrace, Great Yarmouth.
Macmillan, Messrs., Cambridge.
McMorran, A., Esq., Cheapside, E.C.
Macredie, P. B. M., Esq., Perceton House, Irvine, N.B.
Madras Government Museum (per Messrs. Williams and Norgate).
Major, Charles, Esq., Red Lion Wharf, Upper Thames Street, E.C.
Mann, C. S., Esq., F.G.S., Eltham, Kent, S.E.
Mansel, John, Esq., F.G.S., Longthorns, Blandford, Dorset.
Marès, Mons. P., Paris.
Marshall, James G., Esq., F.G.S., Headingley, near Leeds.
Marshall, Matthew, Esq., Bank of England, E.C.
Marshall, Reginald D., Esq., Cookridge Hall, Leeds.
Marsham, Hon. Robert, F.G.S., The Moat, Maidstone.
Martin, Miss, Bredon's Norton, near Tewkesbury.
Mathews, W., jun., Esq., F.G.S., *Local Secretary*, Edgbaston, Birmingham.
Maton, Professor B.
Matthieson, James, Esq., 22, Belitha Villas, Barnsbury Park, N.
Maw, G., Esq., F.S.A., L.S., G.S., Benthall Hall, Broseley, Salop.
Meade, Rev. R. J., Castle Cary.
Merian, Professor Dr. Pierre, F.M.G.S., Directeur du Muséum, Basle.
Meryon, Edward, M.D., F.G.S., 14, Clarges Street, W.
Mildred, Mrs., Preston, Cirencester.
Millar, John, M.D., F.L.S., G.S., Bethnall House, Cambridge Road, N.E.
Milne-Edwards, Dr. Henry, F.M.G.S., Paris.
Mitchell, F. J., Esq., Llanbrechba Grange, Newport, Monmouthshire.
Mitchell, W. S., Esq., LL.B., F.L.S., G.S., New University Club, St. James's Street, S.W.
Mitchenson, Rev. John, D.C.L., King's School, Canterbury.
Möller, Captain Valerian, Institut des Mines, St. Petersburg.
Monk, James, Esq., Aden Cottage, Durham.
Moore, J. Carrick, Esq., M.A., F.R.S., G.S., &c., 113, Eaton Square, S.W.
Moore, Charles, Esq., F.G.S., 6, Cambridge Place, Widcome Hill, Bath.
Moore, Joseph, Esq., Grasmere Lodge, Lower Tulse Hill, S.
Morgan, William, Esq., Bryn Nant, Swansea.
Morton, George Highfield, Esq., F.G.S., *Local Secretary*, 5, London Road, Liverpool.
Mosley, Sir Oswald, Bart., D.C.L., F.L.S., G.S., &c., Rolleston Hall, Burton-on-Trent.
Murchison, Sir R. I., Bart., K.C.B., G.C.St.S., D.C.L., M.A., F.R.S., G.S., L.S., &c., *Vice President*, 16, Belgrave Square, S.W.
Murdock, James Barclay, Esq., 33, Lynedoch Street, Glasgow.
Museum of Irish Industry, St. Stephen's Green, Dublin.
Museum of Practical Geology, Jermyn Street, S.W.
Mushet, Robert, Esq., F.G.S., Royal Mint, Little Tower Hill, E.

Nantes, Musée d'Histoire Naturelle de.
Neale, Edward Vansittart, Esq., West Wickham, Kent.
Nicholl, W. A., Esq., Ham Court, Glamorganshire.
Norfolk and Norwich Literary Institution, Norwich.
Nottingham Literary and Philosophical Society, School of Art, Nottingham.

Nunneley, Thomas, Esq., *Local Secretary*, 22, Park Place, Leeds.
Nutt, D., Esq., Strand, W.C.

Oldham, Mrs., 58, Churchgate, Stockport.
Oldham, Thomas, Esq., F.R.S., F.G.S., &c., 18, Pembroke Road, Dublin.
Oñate, Countess of, Madrid.
Ormerod, G. W., Esq., M.A., F.G.S., &c., Chagford, Exeter.
Oswestry Naturalists' Field Club, Oswestry.
Owen, Professor R., M.D., LL.D., F.R.S., L.S., G.S., &c., *Vice-President*, British Museum, W.C.

Paine, Mrs. J. M., Farnham, Surrey.
Papillon, Rev. J., Rectory, Lexden, Colchester.
Parker, J., Esq., F.G.S., Turl Street, Oxford.
Parry, Thomas G., Esq., F.G.S., Highnam Court, near Gloucester.
Pattison, S. R., Esq., F.G.S., 50, Lombard Street, E.C.
Paynter, Rev. Samuel, Stoke Hill, Guildford, Surrey.
Pearson, Sir Edwin, K.H., M.A., F.R.S., &c., Wimbledon, S.W
Pease, Thomas, Esq., F.G.S., Henbury Hill, near Bristol.
Peckover, Algernon, Esq., F.L.S., Wisbeach.
Pengelly, William, Esq., F.R.S., G.S., *Local Secretary*, Torquay.
Penny, Rev. James, M.A., &c., Blandford.
Penruddocke, Charles, Esq., Compton Park, near Salisbury.
Perceval, Spencer George, Esq., Severn House, Henbury, Bristol.
Perkins, Rev. R. B., Wootton-Underedge, Gloucestershire.
Phillips, John, M.A., LL.D., F.R.S., G.S., &c., Professor of Geology in the University of Oxford, *Vice-President*, Museum, Oxford.
Philosophical Society of Glasgow.
Phear, Rev. George, F.G.S., Emmanuel College, Cambridge.
Phené, John S., Esq., 34, Oakley Street, Chelsea, S.W.
Pickering, John, Esq., 29, Loraine Road, Upper Holloway, N.
Pictet, Mons. F. J., Professor of Zoology, Academy of Geneva.
Pidgeon, Jonathan S., Esq., Pembridge Villa, Bayswater, W.
Plant, James, Esq., *Local Secretary*, 40, West Terrace, West Street, Leicester.
Pollock, Lady, Clapham Common, S.
Portal, Wyndham S., Esq., Malshanger House, Basingstoke.
Porter, Henry, M.D., F.G.S., Peterborough.
Portman, Hon. Miss, 5, Princes Gate, Hyde Park, S.W.
Poynton, Rev. Francis, Rectory, Kelston, Bath.
Prestwich, Joseph, Esq., F.R.S., G.S., 10, Kent Terrace, Regent's Park Road, N.W.
Pritchard, Rev. C., M.A., F.R.S., G.S., &c., Hurst Hill, Freshwater, Isle of Wight.
Prout, Rev. E., F.G.S., &c., Fairfield, Torquay.
Powrie, James, Esq., F.G.S., Reswallie, Forfar.
Provis, William A., Esq., F.G.S., The Grange, Ellesmere, Salop.

Quaritch, B., Esq., Piccadilly, W.
Queen's College, Cork (by Messrs. Hodges and Smith).
Queen's College, Galway.

Queen's College, Oxford.

Raban, Capt. R. B., Shirehampton, Bristol.
Radcliffe Library, Oxford.
Ramsay, Mrs. Wm., Rannagubzion, Blairgowrie.
Ramsay, Professor A. C., LL.D., F.R.S., G.S., &c., Museum Pract. Geology, Jermyn Street, S.W.
Ransome, Robert Charles, Esq., Ipswich.
Regnès, Mons., Paris.
Renevier, Mons. E., Professor of Geology, Academy of Lausanne, Switzerland.
Richardson, James, Esq., Glaurafon, Swansea.
Richardson, William, Esq., High Field, Southouram, near Halifax.
Ricketts, Charles, M.D., F.G.S., 22, Argyle Street, Birkenhead.
Ripon Scientific Society.
Risley, Rev. William Cotton, M.A., Deddington, Oxfordshire.
Robbins, George, Esq., F.G.S., Midford Castle, near Bath.
Rofe, John, Esq., F.G.S., &c., 7, Queen Street, Lancaster.
Roper, F. C. S., Esq., F.G.S., L.S., 3, Carlton Villas, Edgeware Road, W.
Rose, C. B., Esq., F.G.S., &c., 28, King Street, Great Yarmouth.
Rothery, H. C., Esq., M.A., F.L.S., 94, Gloucester Terrace, Hyde Park, W.
Rothery, Charles W., Esq., Greta Hall, Keswick.
Royal Artillery Institution, Woolwich, S.E.
Royal College of Surgeons, Lincoln's Inn Fields, W.C.
Royal Dublin Society, Dublin.
Royal Geological Society of Cornwall, Penzance.
Royal Geological Society of Ireland, 2, Foster Place, College Green, Dublin.
Royal Institution of Cornwall, Truro.
Royal Institution of Great Britain, Albemarle Street, W.
Royal Institution, Liverpool.
Royal Institution of South Wales, Swansea.
Royal Irish Academy, 19, Dawson Street, Dublin.
Royal Military College, Sandhurst, Farnborough Station, Hants.
Royal Society of Edinburgh.
Royal Society of London, Burlington House, W.
Rudd, Rev. Leonard H., M.A., Kempsey, Worcester.
Russ, James, Esq., F.G.S., Great Minster Street, Winchester.
Rutter, John, Esq., Ilminster.
Rylands, T. G., Esq., F.L.S., G.S., Heath House, Warrington.

Sabine, General, R.A., F.R.S., L.S., &c., 13, Ashley Place, Westminster, S.W.
Salford Royal Museum and Library, Peel Park.
Salter, J. W., Esq., F.G.S., &c., 8, Bolton Road, Boundary Road, St. John's Wood, N.W.
Sanders, Gilbert, Esq., M.R.I.A., &c., *Local Secretary*, Brockley on the Hill, Monkstown, Co. Dublin.
Sanders, W., Esq., F.R.S., G.S., &c., *Local Secretary*, 21, Richmond Terrace, Clifton, Bristol.
Sanford, W. A., Esq., F.G.S., Nynehead Court, Wellington, Somerset.
Saul, G. T., F.L.S., Bow Lodge, Bow Road, E.
Saunders, James Ebenezer, Esq., F.L.S., G.S., 9, Finsbury Circus, E.C.

Saunders, W. Wilson, Esq., F.R.S., L.S., &c., Lloyd's, E.C.
Savy, Mons. F., *Local Secretary*, 24, Rue Hautefeuille, Paris.
Scarborough Philosophical Society.
Sedgwick, Rev. Adam, M.A., F.R.S., G.S., &c., Cambridge.
Sharman, George, Esq., 9, St. George's Road, Kilburn.
Sharp, John, Esq., F.G.S., *Local Secretary*, Culverden Hill, Tunbridge Wells, Kent.
Sharp, Samuel, Esq., F.G.S., S.A., Dallington Hall, Northampton.
Shaw, John, M.D., F.G.S., &c., Hop House, Boston, Lincolnshire.
Sheppard, T. Byard, Esq., Selwood Cottage, Frome.
Sheppard, Alfred B., Esq., Torquay.
Shipp, W., Esq., *Local Secretary*, Blandford, Dorset.
Sidney Sussex College Library, Cambridge.
Simpson, J. B., Esq., Hedgefield House, Blaydon-on-Tyne.
Skaife, John, Esq., 6, Union Street, Blackburn.
Sloper, G. E., Esq., Devizes.
Smith, Rev. Charles Lesingham, Little Canfield Rectory, near Chelmsford, Essex.
Smith, Captain Robert, Frankford Avenue, Rathgar, Dublin.
Smith, Rev. Urban, Stoney Middleton.
Smithe, J. D., Esq., C.E., F.G.S., Madhopoor, Punjâb (by Messrs. Smith, Elder, and Co.).
St. Peter's College, Cambridge.
Somersetshire Archæological and Natural History Society, Museum, Taunton.
Sopwith, T., Esq., F.R.S., G.S., 103, Victoria Street, S.W.
South Shields Geological Club.
Sowerby, James de Carle, Esq., F.L.S., &c., Royal Botanic Gardens, Regent's Park, N.W.
Spicer, Henry, Esq., jun., 68, Upper Thames Street, E.C.
Spink, J., Esq., Drax, Selby.
Spragge, W. Kennaway, Esq., the Quarry, Paignton, South Devon.
Steedman, John, Esq., Charlestown by Dunfermline.
Stewart, Mrs. Elizabeth, 42, King Street, Lancaster.
Stobart, W. C., Esq., Etherley House, Darlington.
Stoddart, W. W., Esq., F.G.S., 9, North Street, Bristol.
Stubbs, Charles E., Esq., Henley-on-Thames.
Studer, Herr B., For.M.G.S., Professor of Geology, Berne.
Sunderland Corporation Museum.
Sunderland Geological Society.
Sunderland Subscription Library.
Swayne, H. J. F., Esq., The Island, Wilton, Wilts.

Tate, Geo., Esq., F.G.S., Alnwick, N.B.
Tawney, E. B., Esq., F.G.S., Luleston, Bridgend, South Wales.
Taylor, S. Watson, Esq., Erlestoke Park, Devizes.
Tennant, Professor Jas., F.G.S., &c., 149, Strand, W.C. (*Two Copies*).
Teuchner, Professor.
The General Administration of Mines and Salt-works in Munich (by Messrs. Williams and Norgate).
Thomas, Capt. F. W. L., R.N., H.M.S. " Woodlark," Trinity, near Edinburgh.
Thompson, Miss S., Stamford.
Thompson, Thomas, Esq., Hull.

Thomson, Alexander, Esq., F.R.S.E., Banchory House, Aberdeen.
Thomson, Professor Wyville, LL.D., F.G.S., Queen's College, Belfast.
Tomes, John, Esq., 37, Cavendish Square, W.
Torquay Natural History Society.
Traquair, Professor R. H., M.D., Royal Agricultural College, Cirencester.
Trautschold, Dr., Moscow.
Trevelyan, Sir W. C., Bart., F.G.S., Wellington, Newcastle-on-Tyne; and Athenæum Club, S.W.
Trinity College, Cambridge.
Turner, E. J., Esq., Fairlight Villas, Clapham, S.
Twamley, Charles, Esq., F.G.S., 6, Queen's Road, Gloucester Gate, Regent's Park, N.W.
Tyler, Chas., Esq., F.L.S., G.S., 24, Holloway Place, Holloway, N.
Tylor, Alfred, Esq., F.L.S., G.S., Warwick Lane, Newgate Street, E.C.

University of Edinburgh.
University of Glasgow.
University Library, Aberdeen.
University Library, St. Andrew's.
University Library, Leipzig.

Verneuil, Mons. Edouard de, Mem. de l'Instit., F.M.G.S., 57, Rue de la Madeleine, Paris.
Vernon Park Museum, Stockport.
Vicary, William, Esq., F.G.S., The Priory, Colleton Crescent, Exeter.

Wadge, Captain, Trinity College, Dublin.
Wall, Geo. P., Esq., F.G.S., Pitmoor, near Sheffield.
Walmstedt, Dr. L. P., Professor of Mineralogy, Upsala.
Walton, William, Esq., 11, Paragon, Blackheath, S.E.
Walton, William, Esq., *Local Secretary*, 17, Grosvenor Place, Bath.
Ward, N. B., Esq., F.R.S., L.S., &c., 14, Clapham Rise, S.
Ward, Henry, Esq., F.G.S., Oaklands, Wolverhampton.
Wardle, Thos., Esq., F.G.S., St. Edward Street, Leek.
Waring, Samuel Long, Esq., F.G.S., The Oaks, Norwood, Surrey, S.
Warrington Museum and Library.
Warwickshire Natural History Society, Warwick.
Watson, Rev. R. B., F.G.S., 4, Bruntsfield Place, Edinburgh.
West, G. Herbert, Esq., B.A., F.G.S., 61, Wimpole Street, W.
Wetherell, N. T., Esq., F.G.S., &c., Highgate, N.
White, Alfred, Esq., F.L.S., &c., Castle Street, Cow Cross, E.C.
Willaume, T. B. T., Esq., jun., 24, Chester Terrace, Regent's Park.
Willcock, J. W., Esq., 6, Stone Buildings, Lincoln's Inn, W.C.
Williams and Norgate, Messrs., Henrietta Street, Covent Garden, W.C.
Willis and Sotheran, Messrs., Strand, W.C.
Wilson, J. M., Esq., B.A., F.G.S., Rugby.
Wilson, Rev. Dr. W., Southampton.

Wiltshire, Rev. Thomas, M.A., F.L.S., G.S., &c., *Honorary Secretary*, 13, Granville Park, Lewisham, Kent, S.E.
Winstone, Benjamin, M.D., 7, Ely Place, Holborn, E.C.
Witts, Rev. E. F., F.G.S., Rectory, Upper Slaughter, near Stow-on-the-Wold.
Winwood, Rev. Henry H., F.G.S., 4, Cavendish Crescent, Bath.
Wolley, Rev. Charles, Eton College.
Wood, Edward, Esq., F.G.S., R.S.L., &c., *Local Secretary*, Richmond, Yorkshire.
Wood, Henry, Esq., 10, Cleveland Square, Bayswater, W.
Wood, Rev. Henry H., F.G.S., Holwell Rectory, Sherborne, Dorset.
Wood, Rev. J. E. Tenison, F.G.S., Penola, South Australia.
Wood, S. V., Esq., F.G.S., &c., *Treasurer*, Brentwood, Essex.
Woodall, Capt. J. W., M.A., F.G.S., &c., St. Nicholas House, Scarborough.
Woodd, C. H. L., Esq., F.G.S., S.A., &c., Hillfield, Hampstead, N.W.
Woodward, Charles, Esq., F.R.S., 10, Compton Terrace, Islington, N.
Woodward, Henry, Esq., F.G.S., Z.S., British Museum, W.C.
Worcestershire Natural History Society, Foregate, Worcester.
Wright, Joseph, Esq., F.G.S., 40, Duncan Street, Cork.
Wright, Thomas, M.D., F.R.S.E., G.S., *Local Secretary*, St. Margaret's Terrace, Cheltenham.

Yates, James, Esq., M.A., F.R.S., L.S., G.S., Lauderdale House, Highgate, N.
Yorkshire Naturalists' Club, York (by Ed. Smallwood, Esq.).
Yorkshire Philosophical Society, York.
Young, James, Esq., Burr Street, Tower Hill, E.

Zoological Society of London, 11, Hanover Square, W.

CATALOGUE OF WORKS

ALREADY PUBLISHED BY

THE PALÆONTOGRAPHICAL SOCIETY:

Showing the Order *of publication; the* Years *during which the Society has been in operation; and the* Contents *of each yearly Volume.*

Vol. I. Issued for the Year	1847	The Crag Mollusca, Part I, Univalves, by Mr. S. V. Wood, 21 plates.
„ II. „	1848	The Reptilia of the London Clay, Part I, Chelonia, &c., by Profs. Owen and Bell, 38 plates. The Eocene Mollusca, Part I, Cephalopoda, by Mr. F. E. Edwards, 9 plates.
„ III. „	1849	The Entomostraca of the Cretaceous Formations, by Mr. T. R. Jones, 7 plates. The Permian Fossils, by Prof. Wm. King, 29 plates. The Reptilia of the London Clay, Part II, Crocodilia and Ophidia, &c., by Prof. Owen, 18 plates. The Fossil Corals, Part I, London Clay, by Messrs. Milne-Edwards and Jules Haime, 11 plates.
„ IV. „	1850	The Crag Mollusca, Part II, No. 1, by Mr. S. V. Wood, 12 plates. The Mollusca of the Great Oolite, Part I, Univalves, by Messrs. Morris and Lycett, 15 plates. The Fossil Brachiopoda, Part III, No. 1, Oolitic and Liassic, by Mr. Davidson, 13 plates.
„ V. „	1851	The Reptilia of the Cretaceous Formations, by Prof. Owen, 39 plates. The Fossil Corals, Part II, Oolitic, by Messrs. Milne-Edwards and Jules Haime, 19 plates. The Fossil Lepadidæ, by Mr. Charles Darwin, 5 plates.
„ VI. „	1852	The Fossil Corals, Part III, Permian and Mountain-limestone, by Messrs. Milne-Edwards and Jules Haime, 16 plates. The Fossil Brachiopoda, Part I, Tertiary, by Mr. Davidson, 2 plates. The Fossil Brachiopoda, Part II, No. 1, Cretaceous, by Mr. Davidson, 5 plates. The Fossil Brachiopoda, Part III, No. 2, Oolitic and Liassic, by Mr. Davidson, 5 plates. The Eocene Mollusca, Part II, Pulmonata, by Mr. F. E. Edwards, 6 plates. The Radiaria of the Crag, London Clay, &c., by Prof. E. Forbes, 4 plates.

CATALOGUE OF WORKS—Continued.

Vol. VII. Issued for the Year 1853	The Fossil Corals, Part IV, Devonian, by Messrs. Milne-Edwards and Jules Haime, 10 plates. The Fossil Brachiopoda, Introduction to Vol. I, by Mr. Davidson, 9 plates. The Mollusca of the Chalk, Part I, Cephalopoda, by Mr. D. Sharpe, 10 plates. The Mollusca of the Great Oolite, Part II, Bivalves, by Messrs. Morris and Lycett, 8 plates. The Mollusca of the Crag, Part II, No. 2, Bivalves, by Mr. S. V. Wood, 8 plates. The Reptilia of the Wealden Formations, Part I, Chelonia, by Prof. Owen, 9 plates.
„ VIII. „ *1854	The Fossil Brachiopoda, Part II, No. 2, Cretaceous, by Mr. Davidson, 8 plates. The Reptilia of the Wealden Formations, Part II, Dinosauria, by Prof. Owen, 20 plates. The Mollusca of the Great Oolite, Part III, Bivalves, by Messrs. Morris and Lycett, 7 plates. The Fossil Corals, Part V, Silurian, by Messrs. Milne-Edwards and Jules Haime, 16 plates. The Fossil Balanidæ and Verrucidæ, by Mr. Charles Darwin, 2 plates. The Mollusca of the Chalk, Part II, Cephalopoda, by Mr. D. Sharpe, 6 plates. The Eocene Mollusca, Part III, No. 1, Prosobranchiata, by Mr. F. E. Edwards, 8 plates.
„ IX. „ †1855	The Mollusca of the Crag, Part II, No. 3, Bivalves, by Mr. S. V. Wood, 11 plates. The Reptilia of the Wealden Formations, Part III, by Prof. Owen, 12 plates. The Eocene Mollusca, Part III, No. 2, Prosobranchiata, continued, by Mr. F. E. Edwards, 4 plates. The Mollusca of the Chalk, Part III, Cephalopoda, by Mr. D. Sharpe, 11 plates. The Tertiary Entomostraca, by Mr. T. R. Jones, 6 plates. The Fossil Echinodermata, Part I, Oolitic, by Dr. Wright, 10 plates.
„ X. „ 1856	The Fossil Echinodermata, Part II, Oolitic, by Dr. Wright, 12 plates. The Fossil Crustacea, Part I, London Clay, by Prof. Bell, 11 plates. The Fossil Brachiopoda, Part IV, Permian, by Mr. Davidson, 4 plates. The Fossil Brachiopoda, Part V, No. 1, Carboniferous, by Mr. Davidson, 8 plates. The Reptilia of the Wealden Formations, Part IV, by Prof. Owen, 11 plates. The Reptilia of the London Clay (Supplement), by Prof. Owen, 2 plates.
„ XI. „ 1857	The Fossil Echinodermata, Part III, Oolitic, by Dr. Wright, 14 plates. The Fossil Brachiopoda, Part V, No. 2, Carboniferous, by Mr. Davidson, 8 plates. The Reptilia of the Wealden Formations, Part V, by Prof. Owen, 12 plates. The Polyzoa of the Crag, by Prof. Busk, 22 plates.
„ XII. „ 1858	The Fossil Echinodermata, Part IV, Oolitic, by Dr. Wright, 7 plates. The Eocene Mollusca, Part III, No. 3, Prosobranchiata continued, by Mr. F. E. Edwards, 6 plates. The Reptilia of the Cretaceous and Purbeck Formations, by Prof. Owen, 8 plates. The Fossil Brachiopoda, Part V, No. 3, Carboniferous, by Mr. Davidson, 10 plates.
„ XIII. „ 1859	The Fossil Brachiopoda, Part V, No. 4, Carboniferous, by Mr. Davidson, 20 plates. The Reptilia of the Oolitic Formations, No. 1, by Prof. Owen, 7 plates. The Eocene Mollusca, Part IV, No. 1, Bivalves, by Mr. S. V. Wood, 13 plates.

* This Vol. is marked on the outside 1855.

† This Vol. is marked on the outside 1856.

CATALOGUE OF WORKS—Continued.

Vol. XIV. Issued for the Year	1860	The Fossil Brachiopoda, Part V, No. 5, Carboniferous, by Mr. Davidson, 8 plates. The Reptilia of the Oolitic Formation, No. 2, by Prof. Owen, 12 plates. The Fossil Estheriæ, by Prof. Rupert Jones, 5 plates. The Fossil Crustacea, Part II, Gault and Greensand, by Prof. Bell, 11 plates.
„ XV. „	1861	The Fossil Echinodermata, Vol. II, Part I (Oolitic Asteroidea), by Dr. Wright, 13 plates. Supplement to the Great Oolite Mollusca, by Dr. Lycett, 12 plates.
„ XVI. „	1862	The Fossil Echinodermata, Cretaceous, Vol. I, Part I, by Dr. Wright, 11 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part I, by Mr. J. W. Salter, 6 plates. The Fossil Brachiopoda, Part VI, No. 1, Devonian, by Mr. Davidson, 9 plates. The Eocene Mollusca, Part IV, No. 2, Bivalves, by Mr. S. V. Wood, 7 plates. The Reptilia of the Cretaceous and Wealden Formations (Supplements), by Prof. Owen, 10 plates.
„ XVII. „	1863	The Trilobites of the Silurian, Devonian, &c., Formations, Part II, by Mr. J. W Salter, 8 plates. The Fossil Brachiopoda, Part VI, No. 2, Devonian, by Mr. Davidson, 11 plates. The Belemnitidæ, Part I, Introduction, by Prof. Phillips. The Reptilia of the Liassic Formations, Part I, by Prof. Owen, 16 plates.
„ XVIII. „	1864	The Fossil Echinodermata, Vol. II, Part II (Liassic Ophiuroidea), by Dr. Wright, 6 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part III, by Mr. J. W. Salter, 11 plates. The Belemnitidæ, Part II, Liassic Belemnites, by Prof. Phillips, 7 plates. The Pleistocene Mammalia, Part I, Introduction, Felis spelæa, by Messrs. W. Boyd Dawkins and W. A. Sanford, 5 plates. Title-pages, &c., to the Monographs on the Reptilia of the London Clay, Cretaceous, and Wealden Formations.
„ XIX. „	1865	The Crag Foraminifera, Part I, No. 1, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady, 4 plates. Supplement to the Fossil Corals, Part I, Tertiary, by Dr. Duncan, 10 plates. The Fossil Merostomata, Part I, Pterygotus, by Mr. H. Woodward, 9 plates. The Fossil Brachiopoda, Part VII, No. 1, Silurian, by Mr. Davidson, 12 plates.
„ XX. „	1866	Supplement to the Fossil Corals, Part IV, No. 1, Liassic, by Dr. Duncan, 11 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part IV (Silurian), by Mr. J. W. Salter, 6 plates. The Fossil Brachiopoda, Part VII, No. 2, Silurian, by Mr. Davidson, 10 plates. The Belemnitidæ, Part III, Liassic Belemnites, by Prof. Phillips, 13 plates.
„ XXI. „	1867	Flora of Carboniferous Strata, Part I, by Mr. E. W. Binney, 6 plates. Supplement to the Fossil Corals, Part IV, No. 2, Liassic, by Dr. Duncan, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part II, by Dr. Wright, 14 plates. The Fishes of the Old Red Sandstone, Part I, by Messrs. J. Powrie and E. Ray Lankester, 5 plates. The Pleistocene Mammalia, Part II, Felis spelæa, continued, by Messrs. W. Boyd Dawkins and W. A. Sanford, 14 plates.

LIST OF MONOGRAPHS

Completed, in Preparation, and in course of Publication.*

MONOGRAPHS which have been COMPLETED:—

The Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne-Edwards and J. Haime.
The Tertiary Echinodermata, by Professor Forbes.
The Fossil Cirripedes, by Mr. C. Darwin.
The Tertiary Entomostraca, by Prof. T. Rupert Jones.
The Cretaceous Entomostraca, by Prof. T. Rupert Jones
The Fossil Estheriæ, by Prof. T. Rupert Jones.
The Polyzoa of the Crag, by Mr. G. Busk.
The Tertiary, Cretaceous, Oolitic, Liassic, Permian, Carboniferous, and Devonian Brachiopoda, by Mr. T. Davidson.
The Mollusca of the Crag, by Mr. S. V. Wood.
The Great Oolite Mollusca, by Professor Morris and Mr. J. Lycett.
The Cretaceous (Upper) Cephalopoda, by Mr. D. Sharpe.
The Fossils of the Permian Formation, by Professor King.
The Reptilia of the London Clay (and of the Bracklesham and other Tertiary Beds), by Professors Owen and Bell.
The Reptilia of the Cretaceous, Wealden, and Purbeck Formations, by Professor Owen.

MONOGRAPHS which are in course of PREPARATION:*—

The Flora of the Tertiary Formation, by Mr. W. S. Mitchell.
The Cretaceous Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady.
The Foraminifera of the Lias, by Mr. H. B. Brady.

* Members having specimens which might assist the authors in preparing their respective Monographs are requested to communicate in the first instance with the Honorary Secretary.

MONOGRAPHS in course of PREPARATION—*Continued.*

The Graptolites, by Professor Wyville Thomson.
The Crinoidea, by Professor Wyville Thomson.
The Post-Tertiary Entomostraca, by the Rev. H. W. Crosskey and Messrs. G. S. Brady and D. Robertson.
The Wealden, Purbeck, and Jurassic Entomostraca, by Messrs. T. Rupert Jones and G. S. Brady.
The Bivalve Entomostraca of the Carboniferous Formations, by Messrs. T. Rupert Jones and J. W. Kirkby.
The Phyllopoda of the Palæozoic Rocks, by Mr. J. W. Salter.
The Polyzoa of the Chalk Formation, by Mr. G. Busk.
The Post-Tertiary Mollusca, by Mr. J. Gwyn Jeffreys.
The Cretaceous Mollusca (exclusive of the Brachiopoda), by the Rev. T. Wiltshire.
The Purbeck Mollusca, by Mr. R. Etheridge.
The Inferior Oolite Mollusca, by Mr. R. Etheridge.
The Rhætic Mollusca, by Mr. R. Etheridge.
The Liassic Gasteropoda, by Mr. Ralph Tate.
The Ammonites of the Lias, by Dr. Wright.
The Cetacea of the Crag, by Professor Owen.

MONOGRAPHS in course of PUBLICATION :—

The Flora of the Carboniferous Formation, by Mr. E. W. Binney.
The Crag Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady.
Supplement to the Fossil Corals, by Dr. Duncan.
The Echinodermata of the Oolitic and Cretaceous Formations, by Dr. Wright.
The Fossil Merostomata, by Mr. H. Woodward.
The Trilobites of the Mountain-Limestone, Devonian, and Silurian Formations, by Mr. J. W. Salter.
The Eocene Mollusca, by Messrs. F. E. Edwards and S. V. Wood.
The Silurian Brachiopoda, by Mr. Davidson.
The Belemnites, by Professor Phillips.
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester.
The Pleistocene Mammalia, by Messrs. Boyd Dawkins and W. A. Sanford.
The Reptilia of the Liassic Formations, by Professor Owen.

Dates of the Issue of the Yearly Volumes of the Palæontographical Society.

The Volume	for 1847	was	issued	to the	Members,	March, 1848.
„	1848	„		„	„	July, 1849.
„	1849	„		„	„	August, 1850.
„	1850	„		„	„	June, 1851.
„	1851	„		„	„	June, 1851.
„	1852	„		„	„	August, 1852.
„	1853	„		„	„	December, 1853.
„	1854	„		„	„	May, 1855.
„	1855	„		„	„	February, 1857.
„	1856	„		„	„	April, 1858.
„	1857	„		„	„	November, 1859.
„	1858	„		„	„	March, 1861.
„	1859	„		„	„	December, 1861.
„	1860	„		„	„	May, 1863.
„	1861	„		„	„	May, 1863.
„	1862	„		„	„	August, 1864.
„	1863	„		„	„	June, 1865.
„	1864	„		„	„	April, 1866.
„	1865	„		„	„	December, 1866.
„	1866	„		„	„	June, 1867.
„	1867	„		„	„	June, 1868.

SUMMARY OF THE MONOGRAPHS ISSUED TO THE MEMBERS (*up to* JUNE, 1868): *showing in the* FIRST *column whether each Monograph hitherto published be* complete, *or in the* course of completion; *in the* SECOND *column, the yearly volumes which contain each particular Monograph (as a guide to binding the same); and in the* FIFTH *and following columns, the number of pages, plates, figures, and species described in the different Monographs.*

I. SUBJECT OF MONOGRAPH.	II. Dates of the Years *for which* the Volume containing the Monograph was issued.	III *m*. Dates of the Years of publication on the title-page of each part.	IV *n*. Dates of the Years *in which* the Monograph was published.	V. No. of Pages of Letterpress in each Monograph.	VI. No. of Plates in each Monograph.	VII. No. of Lithographed Figures and of Woodcuts.	VIII. No. of Species described in the Text.
The Flora of the Carboniferous Strata, by Mr. E. W. Binney, in course of completion	1867	1868	1868	32	6	32	2
The Crag Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady, in course of completion	1865	1866	1866	78	4	211	43
Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne-Edwards and J. Haime, *complete* (*k*)	1849, 1851, 1852, 1853, 1854	1850, 1851, 1852, 1853, 1854	1850, 1851, 1852, 1853, 1855	406	72	800	319*g*
Supplement to the Fossil Corals, by Dr. Duncan, in course of completion	1865, 1866, 1867	1866, 1867, 1868	1866, 1867, 1868	144	27	477	91
The Polyzoa of the Crag, by Mr. G. Busk, *complete*	1857	1859	1859	145	22	641	122
The Tertiary Echinodermata, by Prof. Forbes, *complete*	1852	1852	1852	39	4	144	44
The Oolitic Echinodermata, by Dr. Wright. Vol. I, *complete*	1855, 1856, 1857, 1858	1855, 1856, 1859, 1860	1857, 1858, 1859, 1861	474	43	724	109*h*
„ „ Vol. II, in course of completion	1861, 1864	1862, 1866	1863, 1866	154	19	218	29
The Cretaceous Echinodermata, by Dr. Wright. Vol. I, in course of completion	1862, 1867	1864, 1868	1864, 1868	112	25	382	28
The Fossil Cirripedes, by Mr. C. Darwin, *complete*	1851, 1854, 1858*a*	1851, 1854 *	1851, 1855, 1861	137	7	320	54
The Fossil Merostomata, by Mr. H. Woodward, in course of completion	1865	1866	1866	44	9	50	1
The Tertiary Entomostraca, by Prof. Rupert Jones, *complete*	1855	1856	1857	74	6	233	56
The Cretaceous Entomostraca, by Prof. Rupert Jones, *complete*	1849	1849	1850	41	7	176	27
The Fossil Estheriæ, by Prof. Rupert Jones, *complete*	1860	1862	1863	139	5	158	19*i*
The Trilobites of the Mountain-limestone, Devonian, Silurian, and other Formations, by Mr. J. W. Salter, in course of completion	1862, 1863, 1864, 1866	1864, 1865, 1866, 1867	1864, 1865, 1866, 1867	216	31	703	114
The Malacostracous Crustacea (comprising those of the London Clay, Gault, and Greensands), by Prof. T. Bell, in course of completion	1856, 1860	1857, 1862	1858, 1863	88	22	215	50
Fossil Brachiopoda, Vol. I. The Tertiary, Cretaceous Oolitic, and Liassic Brachiopoda, by Mr. T. Davidson, *complete*	1850, 1852, 1853, 1854	1851, 1852, 1853, 1854	1851, 1852, 1853, 1855	409	42	1855	160
„ „ Vol. II. The Permian and Carboniferous Brachiopoda, *complete*	1856*d*, 1857, 1858, 1859, 1860	1857, 1858, 1860, 1861 †	1858, 1859, 1861, 1861, 1863	331	59	1909	157
„ „ Vol. III. The Devonian and Silurian Brachiopoda, in course of completion	1862, 1863, 1865, 1866	1864, 1865, 1866, 1867	1864, 1865, 1866, 1867	299	42	1551	185
The Mollusca of the Crag, by Mr. S. V. Wood:—							
Vol. I. (Univalves), *complete*	1847, 1855*b*	1848	1848, 1857	216	21	581	244
Vol. II. (Bivalves), *complete*	1850, 1853, 1855, 1858*c*	1850, 1853, 1856, 1860	1851, 1853, 1857, 1861	344	31	691	253
The Eocene Mollusca, Cephalopoda and Univalves, by Mr. F. E. Edwards, in course of completion	1848, 1852, 1854, 1855, 1858	1849, 1852, 1854, 1856, 1860	1849, 1852, 1855, 1857, 1861	332	33	578	161
The Eocene Mollusca, Bivalves, by Mr. S. V. Wood, in course of completion	1859, 1862	1861, 1864	1861, 1864	136	20	396	146
The Great Oolite Mollusca, by Prof. Morris and Mr. J. Lycett, *complete*	1850, 1853, 1854	1850, 1853, 1854	1850, 1853, 1855	282	30	846	419
„ „ „ Supplement by Dr. Lycett, *complete*	1861	1863	1863	129	15	537	194
The Belemnites, by Prof. Phillips, in course of completion	1863, 1864, 1866	1865, 1866, 1867	1865, 1866, 1867	88	20	383	48
The Upper Cretaceous Cephalopoda, by Mr. D. Sharpe, *complete*	1853, 1854, 1855	1853, 1854, 1856	1853, 1855, 1857	67	27	319	79
The Fossils of the Permian Formation, by Prof. King, *complete*	1849, 1854*e*	1850*	1850, 1855	287	29	511	138
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester, in course of completion	1867	1868	1868	33	5	72	9
The Reptilia of the London Clay [and of the Bracklesham and other Tertiary Beds], by Profs. Owen and Bell, *complete*‡	1848, 1849, 1856*f*	1849, 1850*	1849, 1850, 1859	150	58	304	39
The Reptilia of the Cretaceous Formations, by Prof. Owen, *complete*‡	1851, 1857, 1858, 1862	1851, 1859, 1860, 1864	1851, 1859, 1861, 1864	184	59	519	26
The Reptilia of the Wealden and Purbeck Formations, by Prof. Owen, *complete*‡	1853, 1854, 1855, 1856, 1857, 1858, 1862	1853, 1854, 1856, 1857, 1859, 1860, 1864	1853, 1855, 1857, 1858, 1859, 1861, 1864	155	62	251	17
The Reptilia of the Oolitic Formations, by Prof. Owen, in course of completion	1859, 1860	1861, 1862	1861, 1863	44	19	88	2
The Reptilia of the Liassic Formations, by Prof. Owen, in course of completion	1863	1865	1865	40	16	62	5
The Pleistocene Mammalia, by Messrs. W. Boyd Dawkins and Mr. W. A. Sanford, in course of completion	1864, 1867	1866, 1868	1866, 1868	166	19	163	1
			TOTAL	6,015	916	16,900	3,391

a Index. *b* Title-page to Univalves. *c* Note to Crag Mollusca. *d* Contains the Permian, which is complete. *e* Two corrections of Plates. *f* Supplement.
g Many of the species are described, but not figured. *h* British species only reckoned. *i* British species only reckoned. *k* A Supplement is now in course of publication.
l Wants Index. *m* Useful in binding up the parts. *n* Useful for establishing the dates of new species. * Dates not given. † Marked 1857–1862.
‡ Title-pages and Index will be found in the 1864 Volume, or may be had separately.

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1867.

LONDON:

MDCCCLXVIII.

OBSERVATIONS

ON THE

STRUCTURE OF FOSSIL PLANTS

FOUND IN THE

CARBONIFEROUS STRATA.

BY

E. W. BINNEY, F.R.S., F.G.S.

PART I.

CALAMITES AND CALAMODENDRON.

PAGES 1—32; PLATES I—VI.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1868.

PRINTED BY J. E. ADLARD, BARTHOLOMEW CLOSE.

CONTENTS.

PAGE

Introductory Remarks 1

Calamites and Calamodendron 3

I. Bibliography 3

II. Remarks on the Specimens 11

1. Geological Position of Specimens Nos. 1—11 11

2. Remarks on Specimens Nos. 1, 2, and 4—11 12

3. Remarks on Specimen No. 3 13

4. General Remarks on Specimens of Calamites and Calamodendron . . 15

5. Remarks on Asterophyllites and its Fructification 17

III. Description of the Specimens Nos. 1—16 19

IV. Concluding Remarks 30

OBSERVATIONS

ON THE

STRUCTURE OF FOSSIL PLANTS

FOUND IN THE

CARBONIFEROUS STRATA.

INTRODUCTORY REMARKS.

When we consider the great number of valuable specimens from the Coal-measures of Great Britain now in our public and private collections, and see what has been done to bring them before the world, we are led to believe that our Carboniferous Fauna and Flora, but more especially the latter, have scarcely had that attention devoted to them which their importance demands. If the curators of our public Museums would describe the specimens under their charge, private collectors describe theirs, and the Council of the Palæontographical Society lend its assistance in publishing, something useful might be effected. In addition, the aid of the colliery-proprietors should be solicited for the purpose of obtaining funds to enable the Palæontographical Society to engage the best artists. When this is done we are likely to possess a literature on our Carboniferous Fossils worthy of the first coal-producing country.

Having specimens of Calamites in my own cabinet, collected by myself, I have been induced to make a small beginning, trusting that some other more competent parties may be induced to follow my example. Knowing the great difficulties that have to be encountered in investigating the nature of the Plants which have formed our beds of coal, my object will be chiefly to describe them, without attempting to trace their analogies with living organisms.

Probably many Members of the Palæontographical Society have specimens in greater number and more perfect preservation than those in my collection, especially as to the branches and roots of *Calamites,* the first genus of fossil plants which it is my intention to describe, but my specimens show structure in a state of perfection that has not often been met with.

On a future occasion other genera of fossil plants may be described and illustrated should an opportunity be afforded me.

My acknowledgments are due to Mr. Cuttell, lapidary, for his skill in slicing and mounting the sections of fossil wood, and to Mr. J. N. Fitch, lithographer, for the care and truthfulness with which he has executed the plates illustrating the specimens.

CALAMITES AND CALAMODENDRON.

I. Bibliography.

§ 1. During many years the genus *Calamites*, so common in our Coal-measures, was generally considered to be a reed-like plant, and hence its name. Very excellent figures of the different species of this genus, with their roots and branches, are given by M. Adolphe Brongniart in his 'Histoire des Végétaux fossiles,' and by Messrs. Lindley and Hutton in the 'Fossil Flora.' All their specimens, however, gave little, if any, evidence of the internal structure of the plant. Afterwards Brongniart, in his 'Tableau des Genres de Végétaux fossiles,' after reviewing the labours of Cotta, Unger, Petzholt, and others, thought it better to divide the genus *Calamites* into *Calamitea* and *Calamodendron*, evidence having been obtained of the outer woody cylinder of the latter, which was not believed to occur in the former.

§ 2. Afterwards Mr. J. S. Dawes, who obtained much more perfect specimens than the Continental authors appear to have possessed, gave a most useful paper on the subject, which is printed in vol. vii of the 'Quarterly Journal of the Geological Society,' and he there states (p. 198) that "on lately examining a specimen of *Sigillaria reniformis*, the tissues appear so much to resemble those of the Calamite as to prove the close connection of these two genera; in fact, all those fossils of this family with the broad outer zones of woody tissue, such as *Calamitea striata* of Cotta, will in all probability prove to be some species of small-ribbed *Sigillaria*."

About the same time Dr. Dawson gave a description of upright *Calamites* found by him near Pictou, Nova Scotia,[1] but he does not adduce any evidence as to their structure or nature.

§ 3. The two last-named authors did not appear to be aware of the publication of a paper by me "On Fossil *Calamites* found standing in an erect position in the Carboniferous Strata near Wigan, Lancashire."[2] In that communication, after describing at length the specimens exposed in the railway-cutting at Pemberton Hill, about two miles

[1] 'Quarterly Journal of the Geological Society,' vol. vii, p. 194, 1851.

[2] Read before the Literary and Philosophical Society of Manchester, July 6, 1847, and printed in the 'London and Edinburgh Philosophical Magazine,' ser. 3, vol. xxxi, pp. 259-266.

west of Wigan, I stated, "In the course of his examination of upright stems of *Sigillariæ* in the Coal-measures, the writer has nearly always found *Calamites* associated with them. At St. Helen's they were abundant, and their bases were found in contact with the main roots of *Sigillariæ*. One of the authors of the 'Fossil Flora,' Mr. Hutton, in describing the Burdiehouse fossils, at page 24, vol. iii, of that work, states as follows:—Amongst vegetables the characteristic fossils of this deposit are *Lepidostrobi*, *Lepidophyllites*, *Lepidodendra*, and *Filicites;* the rarity of *Calamites*, which occur but seldom and of a diminutive size, and the almost entire absence of *Stigmaria*, are very striking to those who are accustomed to view the fossil groups usually presented by the beds of the Carboniferous formation; whilst the profusion of *Lepidostrobi* and *Lepidophyllites*, of various sizes and various stages of growth, associated with the stems of *Lepidodendra*, and those of no other plant, is an additional argument for the opinion, which has always appeared highly probable, that they were the fruit, leaves, and stem of the same tribe of plants. Of *Sigillaria*, a plant which in the flora of the Carboniferous group generally is of so much importance, we could not observe a trace.

"In the course of his own observations the writer has never yet been able to meet with a stem of *Sigillaria* of so small a size as six inches in diameter,[1] or a *Calamites* of so large a size as that. Doubtless there must have been young *Sigillariæ*, whether or not there were large *Calamites*. Now, what are young *Sigillariæ?* This is a question which yet remains to be answered.

"It is now admitted that little is known about the true nature of the genera *Sigillaria* and *Calamites*, except that they were not the hollow succulent stems which they were once supposed to be.

"The rootlets of *Calamites*, as previously shown, if not actually identical with, at least very much resemble, those of *Sigillaria*. In some specimens of the former genus, especially of the species *approximatus*, figured and described in pl. ccxvi, vol. iii, of the 'Fossil Flora,' and the *cruciatus*, figured in pl. xix of Brongniart's 'Histoire des Végétaux fossiles,' their rootlets were arranged in regular quincuncial order. In the largest *Calamites* that to my knowledge has been figured, namely, that called *gigas*, pl. xxvii in Brongniart's work before alluded to, the ribs and furrows begin to appear very like those of *Sigillaria*, and the joints show indistinctly. The termination of the root of a *Calamites* is exactly of the same form as the terminal point of a *Stigmaria*, both being club-shaped.

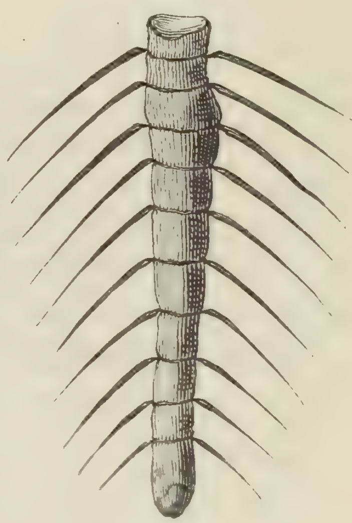
"I am not aware that up to the present time much, if anything, is known of the structure of *Calamites;* but if it should resemble that of *Sigillaria*, it may tend to prove that *Calamites* are but young *Sigillariæ*. In our observations it must not, however, be lost sight of that no central axis or pith has, to my knowledge, yet been discovered in the stem of *Calamites* like that found in *Sigillaria*. Both plants are proved to have

[1] Since the writing of this paper the author has seen in the Museum at Dudley a stem like that of a *Sigillaria* not more than seven inches in diameter.

had similar *habitats*, and therefore it is very probable that they might have had rootlets resembling each other without being the same plant. Still, however, as *Sigillaria* was so long considered as a separate plant from *Stigmaria*, it is unphilosophical to take no notice of the analogies of what are now considered distinct genera. Although it will not by any means be safe to affirm that *Sigillaria* and *Calamites* are the same plant, from their analogies, still it is conceived that sufficient evidence has been adduced in this paper to prove that the latter as well as the former plants have generally grown on the places where they are now found, and that the reason why one is so much more frequently found in an erect position than the other arises from the circumstance of the stem of the one being much stronger than that of the other. A deposit of mud on the branches and leaves of a slender stem of a *Calamites* might weigh it down and prostrate it, whilst the stout trunk of the *Sigillaria* would resist such action and continue erect."

As the specimens near Wigan showed the best roots of *Calamites* found standing as they grew that ever came under my observation, I herewith give in the annexed woodcut (fig. 1) a drawing (reduced one eighth the natural size) made on the spot by my friend the late M. Jobert.

Fig. 1.



§ 4. Dr. C. von Ettingshausen, in 1855, published a most elaborate memoir on *Calamites*,[1] and showed the state of our knowledge at that time of the plant so far as its fruit, branches, and stem were concerned. This author greatly simplified the matter by classing twenty-three species of stems under *Calamites communis*, and subsequent investigations have, in great measure, if not entirely, confirmed his views; but he gives us little information on the structure of the plant, his specimens having been apparently only casts.

§ 5. Dr. Ludwig has given to the world a very lucid description, illustrated by most beautiful plates, of what he considers to be the fructification of *Calamites*.[2] His specimens are in a remarkable state of preservation, and are found associated (but not connected) with a small stem resembling a *Calamites*; this stem, however, scarcely reminds us of the plant as commonly known by that name and so plentifully found in our Coal-measures. The genus *Calamites* has, no doubt, been made to include several plants of very different structures, having external resemblance to each other in some of their characters, and Ludwig's specimen must be taken as the fructification of one of them.

[1] 'Abhandlungen der Kaiserlich-Koniglichen Geologischen Reichsanstalt, Jahrgang,' 1855. Vienna.

[2] "Calamiten-Früchte aus dem Spatheisenstein von Hattingen an der Ruhr," von Rudolph Ludwig; 'Dunker und von Meyer's Palæontographica,' vol. x, 1861 to 1863.

§ 6. Mr. J. W. Salter, F.G.S., in speaking of the Fossil Flora of the Lancashire Coal-fields, says,[1] "The great *Calamites* are common. And this genus appears to have been the most hardy, persistent, and widely diffused of the Palæozoic plants. It began with the *Lepidodendron* in the Devonian, perhaps a little later, and continued far beyond that genus into Triassic times.

"What we see of *Calamites* has been shown by several authors to be only the fluted cast of the pith of *Calamodendron*. But there is much reason to believe that the outer coating was usually very thin, and that the great succulent pith occupied nearly the whole of the stem.

"*Pinnularia* is the root of *Calamites,* as I have convinced myself by specimens during this Survey; and we have now also in Britain the fruit of this interesting genus, such as has been illustrated by Ludwig in vol. x of the 'Palæontographica.'" Mr. Salter gives a drawing of the fruit of *Calamites* from the Lower Coal-measures, Rochdale. The specimen I have not seen; but in the woodcut it exactly resembles the restored one of Ludwig.

§ 7. Professor Schimper, of Strasburg, has been one of the latest authors on the Continent who has treated of *Calamites*.[2] His specimens do not appear to afford much evidence of structure, but his remarks will give us some idea of the opinions there current as to the nature of the plant, and furnish us with the state of knowledge at the time possessed by so distinguished a botanist, who has devoted much attention to the study of both recent and fossil plants, and whose sources of obtaining information on the subject are varied and extensive.

M. Schimper's description is as follows:

"*EQUISETACEÆ.*

"CALAMITEÆ.

"CALAMITES, *Suck.*

"*Caulis cylindraceus, fistulosus, articulatus articulis clausis, sulcatis, sulcis continuatis vel in singulis articulis alternantibus, foliis in vaginam dentatam coalitis vel radiatim patentibus vel nullis* (*?*), *eorumque loco tuberculis* (*foliorum deciduorum pulvinulis seu foliis rudimentariis ?*) *minutis verticillatim dispositis.*

"Tige cylindrique ou à peu près creuse, articulée, à articles fermés par un diaphragme, sillonnée régulièrement dans le sens de la longueur; sillons se continuant directement à

[1] 'Memoirs of the Geological Survey;' "The Geology of the Country around Bolton-le-Moors, Lancashire," p. 43, 1862.

[2] "Description des Espèces de Plantes rencontrées dans le Terrain de Transition des Vosges; par Wm. Ph. Schimper." 'Mémoires de la Société des Sciences naturelles de Strasbourg,' vol. v, p. 323, 1862.

travers les articulations ou alternants ; feuilles verticillées, réunies pour former une gaîne cylindrique ou étalée, plus ou moins profondément dentée, ou nulles (?) et remplacées par des tubercules disposés en verticille (coussinets des feuilles très caduques ou feuilles rudimentaires ?).

"*Subgen.*—Asterocalamites, Schpr.

"*Vaginis profunde dentatis, divisionibus radiatim patentibus; caulis sulcis continuis.* Gaînes profondément dentées à divisions étalées ; sillons de la tige continus.

"Calamites radiatus, *Brgt.*

"Calamites radiatus, *Brongniart. Hist. d. végét. foss.*, I, p. 122, pl. xxvi, 1, 2, 1828.
— — *Unger. Gen. et spec. plant. foss. Vind.*, p. 44, 1850.
Equisetites radiatus, *Sternb. Verst.*, II, p. 45, 1821-38.
— — *Goeppert. Foss. Flor. d. Uebergangsgeb.*, 114, 1852.
Calamites transitionis, *Goepp. Ueber d. foss. Fl. Schles.*, in Wimmer's *Fl. Schlesiens*, II, 1841 ; *ejusd., Fl. d. Uebergangsgeb.*, pp. 116—118, taf. 3, 4, 39, 1852.
— — *Geinitz. Verstein d. Grauwackenform. in Sachsen*, II, S. 28, taf. 18, fig. 6, *u.* 7, 1853; *ejusd., Kohlenform. in Haynischen-Ebersd.*, S. 30, t. 1.
Calamites cannæformis, *Schlth.* Roemer *in* Dunker und v. Meyer's *Palæontogr.*, III, 1, taf. vii, f. 4, 1850.
Bornia transitionis. *Roem. in* Dunk. und v. Meyer's *Palæontogr.* (pro specim. jun.), III, 1, taf. vii, 7, p. 45, 1850.

"*Caulis simplex plus minusve incrassatus, centim.* 1-10 *in diametro metiens, articulationibus cent.* 1-12 *a se invicem distantibus, costis exacte parallelis, subplanis, continuis, vaginis majusculis, infra medium divisis, radiatim expansis; rhizomate ad articulationes cicatricibus singulis rotundatis a ramis caulescentibus provenientibus notato.*

"Tiges simples, offrant un diamètre de 1 à 10 cent., à articulations distantes de 1 à 12 cent., côtes exactement parallèles, presque planes, se continuant en ligne droite à travers les articulations; gaînes assez grandes, divisées jusqu' au-dessous de la moitié de leur longueur, rayonnantes, rhizome marqué aux articulations de cicatrices isolées, provenant de l'insertion des tiges aériennes.

"Cette espèce de Calamite, la seule de genre qui ait été rencontrée dans le terrain houiller inférieur (grauwacke) des Vosges, se reconnaît facilement à ses côtes passant sans interruption à travers les articulations, de sorte que ces dernières ne se distinguent que par un sillon circulaire, accompagné des deux côtés, dans les échantillons un peu forts, d'un renflement plus ou moins évident. La grosseur des tiges rencontrées dans notre terrain varie de 0·01m. à 0·10m. et la distance de leurs articulations se montre peu constante, tant sur les petits que sur les grands individus. La gaîne qui, par son

expansion horizontale et sa division profonde, rappelle un peu la verticille des Astérophyllites, et qui caractérise si bien notre plante, se rencontre très-rarement, parce que, à la suite de sa position naturelle, elle doit toujours rester dans la roche après la séparation de la tige et dans un sens contraire à la position de cette dernière. Pour la trouver il faudrait toujours examiner la roche ambiante et la casser perpendiculairement à la tige, juste à l'endroit qui porte la contre-empreinte d'une articulation, comme cela s'est fait pour l'échantillon conservé dans le Musée d'histoire naturelle de Strasbourg, qui a été figuré pour la première fois par M. Brongniart, dans l' *Histoire des végétaux fossiles*, pl. xxvi, et que j'ai representé de nouveau à la pl. i, fig. *d* et *c*, de ce Mémoire.

"Je crois n'avoir pas besoin d'entrer dans de longs détails pour justifier la réunion du *Calamites transitionis*, Goepp., avec la *Calamites radiatus*, Brgt. Si le hasard n'avait pas fait découvrir la gaîne de ce dernier, personne n'aurait songé à le séparer du premier et encore moins à lui assigner une place dans un genre distinct. Je ne saurais non plus me ranger de l'avis du comte Sternberg et de mon ami Goeppert, en transportant notre fossile dans le genre *Equisetites*, dont il se distingue trop par la forme et la direction de la gaîne, et par la mode de disposition des sillons. Je serais plutôt porté à y voir le prototype des *Asterophyllites*, et c'est pour cela que je propose de le considérer comme type d'un sous-genre avec le nom d'*Asterocalamites*. On n'a aucun exemple qu' un végétal ou animal une fois existant ait disparu pendant un long espace de temps, pour réapparaître plus tard. Cela serait cependant le cas pour le genre *Equisetites*, qui se serait dérobé pendant toute la durée de l'époque houillère proprement dite, pour se montrer de nouveau avec le commencement de l'époque triasique et se conserver de là jusqu' à notre époque.

"Comme en Silésie et dans d'autres localités, notre *Cal. radiatus* caractérise le terrain houiller inférieur des Vosges et y constitue un des fossiles végétaux les plus répandus, surtout dans la vallée de Thann, près de Bitschwiller, d'où nous possédons de nombreux échantillons de toute dimension (Voyez pl. i)."

§ 8. Professor Goeppert has described, under the name of *Aphyllostachys Jugleriana*, the fructification of a plant allied to *Calamites*.[1] Specimens somewhat resembling those described and figured by this learned author are now in my cabinet, and were found by me in both the upper and lower parts of the Carboniferous series, namely, associated with the Spirorbis-limestone in the Manchester coal-field at Ardwick, in the lower Brooksbottom seam of coal,[2] and in the Mountain-limestone of Holywell, in North Wales. These specimens will be described and figured. The second of the specimens above mentioned (No. 12), if not of the same species as Goeppert's, is probably of the same genus.

§ 9. Herr R. Richter, in a Memoir on the Lower Carboniferous Rocks of

[1] Eingegangen bei der Akademie am 11 Mai, 1864. Dresden.

[2] I am indebted to the kindness of Mr. John Aitken for this specimen.

Thuringia,[1] described the structure of *Calamites transitionis* (Goeppert) as consisting of a main woody axis of cellular parenchyma, and a lesser inner axis or hollow cylinder with transverse partitions and corresponding constrictions. The first has a smooth outside, and is formed of cono-cylindrical layers, with indistinct radial divisions, terminating inwards in longitudinal ridges, which give to the smaller axis a longitudinally furrowed exterior. The woody structure and a cone-like fruit of *Calamites transitionis* are figured by Richter.

§ 10. Dr. Dawson has lately published an elaborate paper 'On the Conditions of the Deposition of Coal, more especially as illustrated by the Coal-measures of Nova Scotia and New Brunswick,'[2] wherein he gives his views on *Calamodendron* and *Calamites* in the following words (p. 134):—" *Calamodendron.*—The plants of this genus are quite distinct from *Calamites* proper. A *Calamodendron*, as usually seen, is a striated cast, with frequent cross-lines or joints; but when the whole stem is preserved it is seen that this cast represents merely an internal pith-cylinder, surrounded by a woody cylinder composed in part of scalariform or reticulated vessels, and in part of wood-cells with one row of large pores on each side. External to the wood was a cellular bark; and the outer surface appears to have been simply ribbed in the manner of *Sigillaria.*

"It so happens that the internal cast of the pith of *Calamodendron*, which is really of the nature of a *Sternbergia*, so closely resembles the external appearance of the true *Calamites* as to be constantly mistaken for them. Most of these pith-cylinders of *Calamodendron* have been grouped in the species *Calamites approximatus;* but that species, as understood by some authors, appears also to include true *Calamites* (see Geinitz's 'Steinkohlenformation in Sachsen'), which however, when well preserved, can always be distinguished by the scars of the leaves or branchlets which were attached to the nodes.

" *Calamodendron* would seem, from its structure, to have been closely allied to *Sigillaria*, though, according to Unger, the tissues were differently arranged, and the woody cylinder must have been much thicker in proportion.

" The tissues of *Calamodendron* are by no means infrequent in the coal, and the casts of the pith are common in the sandstones; but its foliage and fruit are unknown. (Fig. 31, Plate VII, *a* to *c*.)

" *Calamites.*—Nine species of true *Calamites* have been recognised in Nova Scotia, of which seven occur at the Joggins; the most abundant being *C. Suckovii* and *C. Cistii.* The *Calamites* grew in dense brakes on sandy and muddy flats. They were unquestionably allied to *Equisetaceæ*, and produced at their nodes either verticillate simple linear

[1] 'Zeitschrift der deutschen geologischen Gesellschaft,' Jahrgang 1864, p. 155. I am indebted to Professor Rupert Jones for calling my attention to this Memoir as these pages were passing through the press.

[2] Read December 20th, 1865. 'Quarterly Journal of the Geological Society,' vol. xxii, pp. 95—169, 1866.

leaves, as in *C. Cistii,* or verticillate branchlets with pinnate or verticillate leaflets, as in *C. Suckovii* and *C. nodosus.* The *Calamites* do not seem to have contributed much to the growth of coal, though their remains are not infrequent in it. The soils in which they most frequently grew were apparently too wet and liable to inundation and silting up to be favorable to coal-accumulation. I have elsewhere shown ('Quart. Journ. Geol. Soc.,' vol. x, p. 34) that some of the species of *Calamites* gave off numerous adventitious roots from the lower parts of their stems, and also multiplied by budding at their bases" (p. 135).

Again, at pp. 140, 141, in treating of discigerous wood-cells, Dr. Dawson says: "These are the true bordered pores characteristic of *Sigillaria, Calamodendron,* and *Dadoxylon.* In the two former genera the discs or pores are large and irregularly arranged, either in one row or several rows. In the latter case they are sometimes regularly alternate and contiguous. In the genus *Dadoxylon* they are of smaller size, and always regularly contiguous in two or more rows, so as to present a hexagonal areolation. Discigerous structures of *Sigillaria* and *Calamodendron* are very abundant in the coal, and numerous examples were figured in my former paper. I have indicated by the name *reticulated tissue* certain cells or vessels which may either be reticulated scalariform vessels, or an imperfect form of discigerous tissue. I believe them to belong to *Stigmaria* or *Calamodendron.* (Figs. 57 and 68, Pl. XII.)"

§ 11. Professor Dr. C. von Ettingshausen[1] has lately described and figured some interesting specimens of *Calamites* showing their branches and leaves, but not affording much evidence of their internal structure.

§ 12. When the present memoir was nearly all written, Mr. Carruthers, after seeing some of my specimens, gave a restored figure of *Calamites* in a paper published in December, 1866,[2] in which he concludes, "It is not easy to find anything analogous to *Calamites* among recent plants; nevertheless its structure does not differ so essentially from the vascular cryptogams as to cause any uncertainty as to its position. The histological character of its wood, the absence of medullary rays, and the nature of its fruit, clearly establish that it was a true cryptogam; and while it differed in the arrangement of the parts of its stem, in its foliar appendages, and in its organs of fructification, from *Lepidodendron,* yet it is evident that these were both near allies, and both more highly organized than any of their living representatives."

[1] 'Die fossile Flora des Nährisch-Schlesischen Dachschiefers; Denkscriften der Kaiserlichen Akademie der Wissenschaften,' Wien, 1866.

[2] "On the Structure and Affinities of Lepidodendron and Calamites," by W. Carruthers, F.L.S., Botanical Department, British Museum; 'Seeman's Botanical Magazine' for December, 1866. In the 'Popular Science Review' for July, 1867, p. 295, &c., Mr. Carruthers has further described and figured the Calamite and its fruit.

II. Remarks on the Specimens.

§ 1. *Geological Position of the Specimens, Nos.* 1 *to* 11.

The Specimens described in this Memoir are sixteen in number; and all those exhibiting structure (with the exception of No. 3, which came from South Owram) were found by me in the lower division of the Lancashire Coal-measures, imbedded in calcareous nodules occurring in seams of coal.

Specimens No. 1, 2, and 4 to 11 are from the same locality as the *Trigonocarpon* described by Dr. J. D. Hooker, F.R.S., and myself in a memoir "On the Structure of certain Limestone-nodules enclosed in seams of Bituminous Coal, with a description of some Trigonocarpons contained therein";[1] and the other specimen, No. 3, is from the same seam of coal in the Lower Coal-measures as that in which the specimens described in a paper entitled "On some Fossil Plants, showing Structure, from the Lower Coal-measures of Lancashire"[2] were met with, but from a different locality, namely, from the "Halifax Hard Seam" at South Owram, marked ** in the section given below. Specimens of *Calamodendron* are also sparingly met with in the "Bullion Mines" near Burnley, marked **,—and in the "Upper Foot Mine," near Oldham, marked ***, in the following vertical sections of Coal-measures.

The position of the seams of coal in which the fossil woods were found in the Carboniferous series is shown by the following sections of the Lower Coal-measures.

In Lancashire.	Yds.	Ft.	In.	*In Yorkshire.*	Yds.	Ft.	In.
Arley or Royley Seam	1	1	0	Beeston or Silkstone Seam	2	0	0
Strata	69	0	0	Strata	77	0	0
Seam	0	0	3	Royds or Black Seam	0	2	10
Strata	57	0	0	Strata	38	0	0
Seam	0	0	6	Better Bed Seam	0	1	4
Strata	45	0	0	Strata	51	0	0
Upper Flagstone (Upholland)	50	0	0	Upper Flagstone (Elland)	40	0	0
Strata	20	0	0	Strata	40	0	0
Seam (90 yards)	0	0	5	Seam (90 yards)	0	0	6

[1] 'Philosophical Transactions,' 1855, p. 149.

[2] 'Quarterly Journal of the Geological Society of London' for May, 1862, vol. xviii, p. 106.

In Lancashire.	Yds.	Ft.	In.	*In Yorkshire.*	Yds.	Ft.	In.
Strata	20	0	0	Strata	56	0	0
Seam (40 yards)	0	1	6	Seam (40 yards)	0	1	0
Strata	64	0	0	Strata	39	0	0
*** Upper Foot Seam (Dog Hill)	0	1	2				
Strata	15	0	0				
** Gannister Seam	1	0	0	** Halifax Hard Seam	0	2	3
Strata	13	0	0	Strata	14	0	0
Lower Foot Seam (Quarlton)	0	2	0	Middle Seam	0	0	11
Strata	17	0	0	Strata	24	0	0
Bassy Seam (New Mills)	0	2	6	Soft Seam	0	1	6
Strata	40	0	0	Strata	56	0	0
Seam	0	0	10				
Strata	10	0	0				
Sand or Featheredge Seam	0	2	0	Sand Seam	0	0	4
" Rough Rock " of Lancashire, " Upper Millstone " of the Geological Survey	20	0	0	" Upper Millstone" of Phillips, Halifax	36	0	0
Strata (Rochdale or Lower Flags)	120	0	0	Strata (Lower Flagstone)	72	0	0
*Seam	0	0	6	Little Seam	0	0	3
Strata	2	0	0				
Seam	0	0	10				
Strata	14	0	0				
Seam	0	1	3				
" Upper Millstone" of Lancashire.							

In the Lancashire Coal-field all the seams of coal from the " Forty Yards" downwards have at places afforded *Aviculopecten* and other marine shells in the roofs of black shale; and these latter strata generally contain calcareous nodules. The nodules in the seams of coal commonly known by the name of " Bullions" have chiefly been found in the beds marked *, **, and *** in Lancashire; whilst in Yorkshire they have as yet been only observed in the " Halifax Hard Seam," marked **.

§ 2. *Remarks on Specimens Nos.* 1, 2, *and* 4 *to* 11.

The specimens showing structure intended to be described in this Memoir are (with the exception of No. 3) from the thin seam of coal marked * in the vertical section of the Lower Coal-measures of Lancashire previously given; and are from the same " mine" or bed from which the specimens described by Dr. Hooker and myself were obtained. They were found associated with *Halonia, Sigillaria, Lepidodendron, Stigmaria, Trigonocarpon, Lycopodites, Lepidostrobus, Medullosa,* and other genera of plants not yet determined. The foregoing are mentioned in the order of their relative abundance.

A portion of one of the specimens of fossil wood on analysis[1] gave

Carbonate of lime	76·66
Carbonate of magnesia	12·87
Sesquioxide of iron	4·95
Sulphate of iron	0·73
Carbonaceous matter	4·95

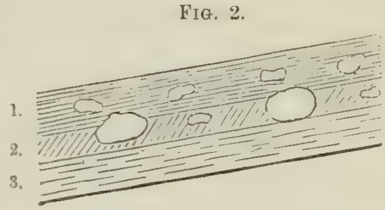
The stratum lying immediately above the seam of coal in which the specimens occurred generally termed the "roof," was composed of black shale, containing large calcareous nodules, and for a distance of about two feet six inches upwards was one entire mass of fossil shells of the genera *Goniatites*, *Orthoceras*, *Aviculopecten*, and *Posidonia*.

The beds in the vicinity of the coal occurred in the following order, namely,

	Yds.	Ft.	In.
1. Black shale, with nodules containing fossil shells	0	2	6
2. Upper seam of coal, enclosing the nodules full of fossil wood	0	0	6
3. Fire-clay floor, full of *Stigmaria*...	0	2	0
4. Clay and rock	2	0	0
5. Lower seam of coal	0	0	10
6. Fire-clay, full of *Stigmaria*.			

The fossil wood occurred in spherical, lenticular, and elongate and flattened nodules, varying from an inch to a foot in diameter; the round and globular specimens being in general small, whilst the flatter nodules were nearly always of a large size. No fossil shells were met with in the nodules found in the coal itself ("2"), although, as previously stated, they were very abundant in the nodules found in the roof ("1") of the seam, which there rarely contained any remains of Plants. The large nodules of ten to twelve inches in diameter, when they occurred, swelled out the seam of coal both above and below, as in the annexed woodcut, fig. 2.

Fig. 2.



§ 3. *Remarks on No. 3 Specimen.*

The third specimen intended to be described in this Memoir is from a small seam of coal, about two feet in thickness, in the Lower Coal-measures, and marked ** in the vertical section at p. 12; and is from the same seam that the specimen of *Sigillaria vascularis* described by me in the paper published in the 'Quarterly Journal of the Geo-

[1] For this analysis I am indebted to the kindness of Mr. Hermann.

logical Society,' previously quoted, came from, although from a different locality. This specimen occurred in the "Halifax Hard Seam" or "Gannister Coal," at South Owram, near Halifax. It was associated with *Sigillaria*, *Stigmaria*, *Lepidodendron*, *Halonia*, *Diploxylon*, *Lepidostrobus*, *Trigonocarpon*, and other fossil Plants not well determined. The above is about the order of relative abundance in which these plants occurred.

A portion of one of the nodules gave on analysis[1]—

Sulphates of potash and soda	1·620
Carbonate of lime	45·610
Carbonate of magnesia	26·910
Bisulphide of iron	11·650
Oxides of iron	13·578
Silica...	0·230
Moisture	0·402

The stratum found lying immediately above the seam of coal in which the nodules occurred was composed of black shale, containing large calcareous concretions, and for about eighteen inches was one entire mass of fossil shells of the genera *Aviculopecten*, *Goniatites*, *Orthoceras*, and *Posidonia*.

The beds occurred in the following (descending) order:

	Ft.	In.
1. Black shale, full of fossil shells and containing calcareous concretions ...	1	6
2. Halifax Hard Seam, with the nodules containing the fossil plants	2	0
3. Floor of fireclay and gannister, full of *Stigmaria ficoides*.		

The fossil wood is found in nodules dispersed throughout the coal; some being spherical, and others elongated and flattened ovals, varying in size from the bulk of a common pea to eight and ten inches in diameter. In some portions of the seam of coal the nodules are so numerous as to render it utterly useless; and they are found to occur over a space of several acres, and then for the most part to disappear, and again to occur as numerous as ever. For the distance of twenty-five to thirty miles the nodules are found in this seam of coal in more or less abundance, but always containing nearly the same plants. Fossil shells are rarely met with in the nodules found in the coal; but they occur abundantly in the large calcareous concretions found in the roof of the "mines," and are there associated with *Dadoxylon* (containing *Sternbergia* piths) and *Lepidostrobus*. So far as my experience extends, the occurrence of nodules in the coal is always associated with that of fossil shells in the roof, and therefore may probably be owing to the presence of mineral matter held in solution in water and precipitated upon, or aggregated around, certain centres in the mass of vegetable matter now forming coal before the bituminization of such vegetables

[1] For this analysis I am indebted to the kindness of Dr. R. Angus Smith, F.R.S., who had it done in his laboratory by Mr. Browning.

took place.[1] No doubt such nodules contain a fair sample of the plants of which the seams of coal in which they are found were formed; and their calcification was most probably due to the abundance of shells afterwards accumulated in the soft mud and then decomposed, and now forming the shale overlying the coal.

At present little is known of the process by which animal and vegetable bodies are decomposed, and the particles of which they were formed removed and exactly replaced by mineral matter. All observers have been struck with the wonderful perfection of the process by which the most microscopic parts of minute vessels and cells have been preserved in form; but no author could satisfactorily account for it until the wonderful discoveries in *Dialysis* by Professor Graham, F.R.S., H.M. Master of the Mint, showed us how crystalloids, such as carbonate of lime, could percolate through animal and vegetable membranes. It is probably by the laws of *Dialysis* that we shall be enabled to find out the process of the calcification of the specimens described in this Memoir.

§ 4. *General Remarks on Specimens of* CALAMITES *and* CALAMODENDRON.

For a long time I have devoted considerable attention to the genus *Calamites*, and have collected a tolerably good suite of specimens which show structure. There is no difficulty in obtaining any quantity of fossil wood, showing the wedge-shaped bundles of pseudo-vascular[2] structure, which, springing in radiating series from certain circular and oval orifices, next the central axis, are parted by wedge-shaped masses of very coarse cellular tissue, increasing in the opposite direction to those first mentioned. It is well known that the casts of the central axis, showing by their ribs and furrows the former position of the wedge-shaped bundles, are found in most of our Coal-measures; but when we look for specimens affording outside characters of the woody cylinder, and examples of the pith or central axis showing structure, we find great difficulty in obtaining them. Most collectors select large specimens, and in these, although we may sometimes be so fortunate as to meet with evidence of the outside of the plant better than a mere carbonaceous film, generally we have not much chance of getting any indication of the pith or central axis. The wedges of pseudo-vascular tissue, proceeding from their radiating orifices, are usually found compressed close together, and the space formerly occupied by the pith or central

[1] For a very excellent account of the petrification of wood, see Dr. Goeppert's 'Die Gattungen der fossilen Pflanzen,' published at Bonn in 1841, a work of great research, and which does not appear to have been much known in England, judging from the few references made to it. This learned author long anticipated me in the discovery of the structure of the rootlets of *Stigmaria*, although I was quite unaware of it when I wrote my paper on the same subject published in the 'Quarterly Journal of the Geological Society,' vol. xv (1859), p. 79.

[2] The term "pseudo-vascular" is taken from Mr. Dawes' paper on *Calamites* published in vol. vii of the 'Quarterly Journal of the Geological Society.' It may be a question whether "vascular" should not be employed.

axis has been assumed to be composed of lax cellular tissue, like *Sigillaria* and *Stigmaria* were supposed to have been. Mr. Dawes, as well as Petzholt, had noticed the transverse divisions in the pith or central axis of *Calamites* at the nodes, and both authors considered the pith to be composed of cellular tissue, with a few vascular bundles in it.

Searchers after fossil plants showing structure must be aware, if they have any great experience, that large specimens have their tissue generally very much distorted and disarranged, and seldom afford any evidence of the central axis or pith, except a mere line, or a cast of mineral matter, in an amorphous condition. My endeavours have been to find very small specimens, for these appear to have undergone less alteration from pressure than larger ones. They vary in size from $\frac{6}{100}$ of an inch in diameter to three inches; and it is only in the very smallest specimens that we find every part of the plant preserved. Transverse sections of small specimens are met with which show only a radiating cylinder of pseudo-vascular tissue of two tubes in breadth, whilst some of the larger ones exhibit a radiating cylinder of upwards of one hundred tubes in breadth.

In the small specimens we have not much chance of seeing the external characters of the stem, and for this we have to resort to larger specimens.

In order to reconstruct the whole of the Plant, it is necessary to build up its parts from different individuals of various sizes. The outside of a small *Calamites* is ribbed and furrowed, and shows nodes or joints; whilst a larger specimen, in its decorticated state, is nearly smooth, or slightly marked with fine longitudinal striæ. The cell-walls of the tubes composing the pseudo-vascular cylinder of the former are thin, and the oval openings not so well defined; whilst in the latter, the cell-walls are stronger, and the elongated openings in them are of a more distinct form. In both large and small specimens the central axis or pith is divided at the joints by horizontal diaphragms. Both have a thick carbonaceous bark, and their pseudo-vascular systems are wedge-shaped, springing from orifices[1] or openings around the central axis.

In this Monograph no attempt will be made to distinguish the genus *Calamodendron* from the old genus of *Calamites;* but, as all my chief specimens show structure, they will be named *Calamodendron.* It was formerly supposed that the larger specimens belonged to the latter genus, and the smaller ones were classed with the former: but my specimens, both large and small, afford only evidence of one kind of structure; and I am, therefore, induced to class both provisionally under one genus in this Memoir.

Other observers may bring forward fresh grounds, from structure, to show that *Calamites* is a distinct plant from the *Calamodendron* herein described. My specimens I have named *Calamodendron commune.*

[1] As I know of no similar arrangement in living plants, I have used the words "orifices" or "openings" in the descriptions, in preference to the terms *nuclei* or *areolæ.*

§ 5. *Remarks on* Asterophyllites *and its* Fructification.

For many years *Asterophyllites* has been known as the leaves of *Calamites*, and numerous specimens have been figured and described by Lindley and Hutton, Brongniart, Ettingshausen, Presl, and others. From the joints of the stem of the plant, at each of the oval spaces around it, proceeded a number of branches, radiating in every direction. These, at their joints, sent out smaller branches, which, at intervals, from lesser joints, again furnished whorls of leaves, with a length of an inch to an inch and a half. The leaves were of the shape of a *Lepidophyllum*, but scarcely so long or so broad; and were marked in the middle by a strong midrib. In my cabinet are some specimens of *Asterophyllites* with leaves longer than have been usually met with; and one of these will be figured, although not from the same locality as the specimens which show structure came from. Unfortunately no well-recognised specimens of the external forms of leaves have yet been met with in the calcareous nodules which afford the fossil stems showing structure.

The fructification of *Asterophyllites* is well shown in some specimens found by me in the red shales of the Upper Coal-measures of Ardwick, near Manchester. A specimen will be figured and described, which throws considerable light on the nature of the plant.

An example of another plant, resembling the *Volkmannia sessilis* of Presl, and allied to *Asterophyllites*, and found in the Mountain-limestone of North Wales, will be given.

By the kindness of my friend, Mr. John Aitken, of Bacup, I am enabled to give the figure of the fructification of another allied plant, found near the Lower Brooksbottom Coal (the lowest in the section previously given, p. 12) by Mr. Henry Stephenson, at Ewood Bridge. This, if not the same as the *Aphyllostachys Jugleriana* of Goeppert, is very nearly allied to it.

The three last-mentioned specimens are all about the same size so far as their cones are concerned; and these agree pretty well with the small cones found in great abundance near the stems of *Calamodendron*, except in being about twice the bulk of the latter; but all four are very short when compared with the long cones of *Flemingites* described and figured by Mr. Carruthers.[1] Most probably this last-named genus had whorls of leaves, like those of *Asterophyllites*, proceeding from a jointed stem, very similar to, but not identical with, that of *Bechera grandis*, figured and described by Lindley and Hutton.

The fructification of *Calamites* has long been supposed to be that known as *Volkmannia*. Some years since, when examining my specimens of *Calamodendron*, showing

[1] "On an undescribed Cone from the Carboniferous beds of Airdrie," 'Geological Magazine,' vol. ii, p. 433, October, 1865.

structures, I noticed numerous small cones lying detached around them in the stone. These I immediately recognised as resembling *Volkmannia*, and showed them to Dr. J. D. Hooker, F.R.S., who also thought that they bore great resemblance to that genus of fossil plants. On further examination, from the structure of the central axis of the cone being the same as that of the stem of *Calamodendron*, it was evident to me that the cone was the fructification of that plant. This was before Dr. Ludwig's paper came under my notice.

My specimens of the organs of fructification will be described at length, as they show structure in all their parts, and exhibit the spores in the sporangia, which Dr. Ludwig's do not, so far at least as described by that author.

The cone is one third of an inch long in my best specimens, although it may have exceeded that length. In one case there are eight sporangium-receptacles, placed one immediately above the other. These receptacles are of a crown-shape, formed by the scales which proceed from the central axis of the cone, at first at right angles, and then, when they reach the outside, taking a vertical direction, somewhat like the scales of *Lepidostrobus*, figured and described by Dr. Hooker[1]; but they are arranged one above another throughout the whole series, and not in a spiral direction. The sporangia are of an irregular egg-shape, slightly elongated, and are arranged in fours, symmetrically, around a thorn-like process or spindle coming from the axis; but I have not been able in my specimens to see them distinctly enveloped in a bladder-shaped bag so plainly as described by Ludwig: but there is clear evidence of such a covering. In each receptacle there are six of these series of four, arranged radially with regard to the central axis; so there are twenty-four sporangia altogether in every receptacle. Each sporangium has a covering composed of a single row of parallel cells, which generally shows evidence of some disturbance, so that the original form of the sporangium is not often well displayed. This is filled with numerous round spore-like bodies, some of them having apparently a tri-radiate appearance, and looking as if they had divided into three sporules. These are not unlike similar spores seen in *Lepidostrobus Browni*; but are more transparent, not so dark in colour, and of smaller size.

The attachment of the bladder-shaped bag, containing the four sporangia, to the spindle is not well seen; but the connection of the latter to the central axis of the cone is clearly shown, and is exactly the same as that described by Dr. Ludwig in his specimen.

The outside of the central axis is composed of tubes of hexagonal and pentagonal forms, having all their sides marked by transverse openings of an elongated oval shape, similar to what are observed on the pseudo-vascular bundles of tubes of *Calamodendron*; but blank spaces show that some portions of the axis have been of a more perishable nature.

[1] 'Mem. Geol. Surv. Great Britain,' vol. ii, part 1, p. 449, plate 7, fig. 8.

The form of the sporangium, when it is of large size, and had attained a state of maturity, is generally of an irregular egg-shape, as before stated; but, in some small specimens, it has a cordate or pear-shape form in tangential sections, and is filled full of dark-coloured spores; and its external cover, composed of a single row of cells, is thicker and more substantial. This envelope appears to have expanded and become thinner as it grew older; and, at length, when the spores were ripe, it probably burst and dispersed them. Specimens of sporangia are to be found in all stages of their growth; but the cones, although generally showing most beautiful structure, have been very much disarranged, and it is extremely difficult to get true sections of them, especially in a longitudinal direction, parallel to their central axis. A great number of specimens had to be examined before the quadrate arrangement of the sporangia, as first shown by Ludwig, could be made out, as well as the occurrence of six processes or spindles in the stead of that author's five, and the twenty-four sporangia against his twenty.

III. Description of the Specimens.

§ 1. The Specimens (*Calamodendron commune*) Nos. 1 and 2.

(No. 1, Plate I, fig. 1; Plate II, figs. 1—6. No. 2, Plate I, fig. 2.)

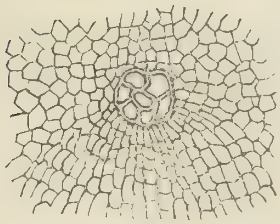
Specimen No. 1 (Plate I, fig. 1) is about eight inches in length, and ten inches in circumference. Although no doubt originally cylindrical, it is now of an irregular pear-shape from the pressure to which it was probably subjected in the process of mineralization. The outside of the fossil, which is in a decorticated state, is marked by fine longitudinal striæ; but it does not show the ribs and furrows so commonly found on what is generally termed the outside of *Calamites,* nor are there any joints or nodes apparent on it. There is some evidence of the outer bark in a thin coating of bright coal, the specimen having shelled out of the matrix in which it was imbedded, and left its bark in the stone. But in another specimen (No. 2; Plate I, fig. 2), from the same place as No. 1 came, we have an example of a *Calamodendron* which has been split through the middle, and which there shows, on the outside of the central axis, the usual ribs and furrows so long considered as belonging to the outside of the plant; and in an upper portion of the specimen, not shown in the Plate, is a joint.

On looking at a transverse section of No. 1 (Plate II, fig. 1), the wedge-shaped bundles of pseudo-vascular structure are seen squeezed together, and divided by other wedge-like masses of coarse cellular tissue, of a lighter colour; but there is no trace left of the central axis (or pith) of the plant. This, as has been previously stated, is nearly always the case with large specimens, so far as my experience goes. In the specimen now under consideration, owing to the position of its fracture, we cannot obtain any

evidence of the cast of the outside of the central axis; but if the specimen were fractured like No. 2, it would most probably in all respects be similar to that figured in Plate I, fig. 2, as to the usual ribs, furrows, joints, and nodes so commonly found on ordinary *Calamites*.

The wedge-shaped bundles of pseudo-vascular tissue originate from a small circular orifice or opening, sometimes simple, as in the specimen now under consideration (Plate II, fig. 2), but in other instances, apparently divided into several parts, as shown in the annexed woodcut[1] (fig. 3); they are composed of quadrangular tubes, arranged in radiating series, and increasing in size as they approach the circumference. These tubes, but hexagonal in section, also extend in an imperfect radiating series some distance from the "orifice" towards the central axis, and increase in size as they approach that point. They are divided by oblique dissepiments, and their walls are much thicker than those found in the inner woody cylinder of *Sigillaria;* and, instead of being covered with fine transverse striæ, both simple and anastomosing, as in that genus of plants, they are marked by oval openings in the sides, horizontal in the longitudinal section, Plate II, fig. 3, and termed by Dr. Dawson "reticulated tissue."[2] These openings are also shown, in a tangential section, in Plate II, fig. 4, taken near the commencement of the wedges of pseudo-vascular tissue. The diameters of the tubes increase gradually from their origin at the orifice, or opening, to their termination at the outside of the cylinder, where they are largest. The number of these wedge-shaped bundles in this specimen (No. 1) is seventy-three, alternating with an equal number of wedge-shaped masses of coarse and lax quadrangular tissue, having their broadest side next to the central axis, and diminishing in size as they extend towards the circumference; the size of the cells thus decreasing in the opposite direction to that of the decrease of the tubes of the pseudo-vascular cylinder, namely, from the central axis to the outside. These can be seen with the naked eye to about $\frac{1}{7}$th of the distance from the central axis to the outside, where they cannot be recognised without the aid of a microscope; but tangential sections of this part of the pseudo-vascular cylinder show that it is traversed by bundles of tissue, oval in section (Plate II, fig. 6) not much unlike in shape to those seen in *Sigillaria vascularis*, but with

FIG. 3.



[1] This cut is from a drawing made by Mr. Bone under the direction of Dr. J. D. Hooker, who after carefully examining these openings, I believe, came to the conclusion that they were passes for a peculiar kind of tissue which has unfortunately been destroyed, rather than the mere cavities which we now see in the specimens.

[2] The openings in the walls of the tubes have a resemblance in shape to Dr. Dawson's left-hand piece in fig. 67, pl. 12 ('Quart. Journ. Geol. Soc.,' vol. xxii); but the walls of the tubes in my specimens are much thicker than those described by Dr. Dawson (op. cit., p. 140, 169). This structure, no doubt, is familiar to all who have carefully examined under the microscope the charcoal in coal.

the marked difference of being composed of cells and not of barred vessels, as is the case in that plant.

The origin of the pseudo-vascular wedges is from the oval orifices, and they seem to have no apparent connection, so far as my observation goes, with the central axis or pith. In small specimens the number of these orifices had been noticed as far as six; whilst in the large specimen now under description, as previously stated, they amount to seventy-five in number. Specimens of these wedge-shaped masses, similar in structure and external character to those of No. 1, can be seen of different sizes from some so small as to consist of only three tubes in breadth (from the orifice to the outside) up to larger ones, with more than one hundred tubes.

The specimen shows what at first sight might be mistaken for annular rings, or depositions of successive growth; but when carefully examining it under the microscope, we do not find in it sufficient evidence to establish with certainty any appearance of the cessation of growth, like that shown by the annular rings of an exogenous plant of the present day. Other specimens in my cabinet give more evidence of successive growths; but still in my opinion scarcely sufficient to establish the former existence of distinct annular rings, showing the stoppage of growth, like that which now takes place in our hard-wooded exogenous trees; and these appearances in the specimen may have been caused, at the time of the mineralisation of the specimen, by successive deposits of mineral matter. However they may have been produced, these rings appear to me to be nearly similar in *Calamodendron* to those usually seen in transverse sections of the external woody cylinder of *Sigillaria*, as well as those in the outsides of *Dadoxylon*.

The tangential section Plate II, fig. 5, is taken near the commencement of the pseudo-vascular bundles, and shows them of small size and divided by broad spaces of coarse cellular tissue. That of Plate II, fig. 6, is taken nearer to the circumference, and shows the pseudo-vascular bundles separated by others of coarse cellular tissue, elongated oval in section. Neither of these sections, however, exhibits the oval-shaped bundles of vessels proceeding from the joints, and communicating with the branches. These will be shown in other specimens, hereinafter described.

§ 2. The Specimen (*Calamodendron commune*) No. 3.

(Plate III, figs. 1—6.)

This is of small size when compared with Nos. 1 and 2 last described, and is exhibited in Plate III, fig. 1, displaying only one side and the top of the specimen. It is one inch in length, and three-tenths of an inch in diameter across its major axis. The outer bark has been converted into a film of bright coal, which adheres to the stony matrix, and thus leaves the outside of the stem in a decorticated state. This stem, unlike

Specimen No. 1, is marked with the usual longitudinal ribs and furrows, interrupted by joints, so commonly met with on the exteriors of ordinary *Calamites.* This difference in the outside appearance of large and small specimens is probably due to the extremities of the pseudo-vascular bundles forming the ribs, and the lax tissue the furrows, in the young specimens; whilst the older individuals, having an exterior composed chiefly of pseudo-vascular tissue without such marked divisions of cellular tissue, do not exhibit such decided ribs and furrows. However different in appearance the outsides of the specimens Nos. 1 and 3 are, we shall presently see that their structure is the same in nearly all respects.

Fig. 2 represents a transverse section of the stem, magnified ten diameters. It is oval in form, and shows twenty-two wedge-shaped masses of pseudo-vascular structure, radiating from twenty-two different orifices, placed outside the central axis at regular distances, and parted by wedge-shaped masses of lax tissue, increasing and diminishing in opposite directions to what obtains in the pseudo-vascular tissue, as previously noticed in the larger specimen No. 1 (p. 20). The tubes composing the latter tissue gradually increase in size as they extend from the orifices towards the circumference; whilst in the lax tissue the cells diminish as they are traced from the outside of the central axis to the exterior.

The central axis has been destroyed, with the exception of two oval-shaped portions of tissue, which, however, are too imperfectly preserved to afford us much evidence of their original structure. Information as to this we shall receive from another and smaller specimen hereinafter described.

Fig. 3 represents a longitudinal section of the pseudo-vascular part of the stem (magnified seven diameters), showing it to have been composed of quadrangular tubes, having their sides marked by oval openings, placed horizontally, like those previously described in No. 1 (p. 20). These tubes, when they approach the joints swell out; but after they have passed those parts they assume their usual size. At the joints a diaphragm of coarse cellular tissue appears to divide the stem horizontally, not much unlike what is found in *Dadoxylon;* but, of course, less frequently, and at greater distances.

Fig. 4 shows a tangential section of the stem, and affords evidence of the structure of three of the bundles (oval in section) of vessels which proceeded from the joints to the branches. These bundles, in their characters, both as to shape and structure, are like those seen traversing the internal woody cylinder of *Sigillaria vascularis,* from the inside to the leaves. This section also shows other masses, of a lighter colour than the body of the specimen, and a more elongated oval shape, composed of three and four cells in breadth. These appear to be extensions of the wedge-shaped masses of lax tissue which divide the bundles of pseudo-vascular tissue near the orifices. One of these is shown magnified forty-five diameters in fig. 6, and will afford a good idea of their general appearance.

Fig. 5 exhibits a longitudinal section of the same stem, magnified fifty diameters. With this magnifying power the walls of the tubes give evidence of oval openings, placed horizontally; but they are scarcely so well defined as those in the large specimen No. 1; and the walls appear to be slighter (even after allowing for the smaller size of the specimen), than those in the specimen first described (p. 20).

The two sections last mentioned, more especially the longitudinal one, are obscured in parts by patches of coaly matter; and, as we should expect from the appearance of the transverse section of the stem, we find that a portion of the central axis has been destroyed, and no trace of its original structure left. The coaly matter is, no doubt, owing to the line of section being taken close to the bark, which is generally found converted into bright coal.

§ 3. The Specimen (*Calamodendron commune*) No. 4.
(Plate III, fig. 7.)

Plate III, fig. 7, shows a very small specimen of *Calamodendron*, magnified thirty-four diameters, with the central axis (or pith) in a complete state of preservation. The diameter at the broadest is only $\frac{6}{100}$th of an inch. The stem, no doubt, was originally cylindrical, like those of all other specimens of this genus of plants; but it has assumed an oval form from pressure when it was in a soft state. The central axis, or pith, is composed of large pentagonal utricles (some filled with a black colouring matter), arranged without order, except that the largest in size is found near the centre. The woody cylinder surrounding the central axis consists of nine wedge-shaped masses of pseudo-vascular structure, radiating from as many orifices, and similar in all respects to that of the two larger specimens, Nos. 1 and 3, previously described (pp. 20 and 22). Indeed it appears to be an individual of the same species, in a younger stage of growth.

The form of the utricles composing the central axis somewhat resembles that found in small specimens of *Sigillaria vascularis*. In all my longitudinal sections of this small stem, I have not been able to satisfy myself that they are marked on their sides by fine horizontal striæ; but still they appear to be different from ordinary cellular tissue, and have more the form of utricles than of cells. This is a very material point to clear up, and probably the examination of other specimens may enable us to elucidate it more satisfactorily.

§ 4. The Specimen (Cone of *Calamodendron commune*) No. 5.
(Plate IV, fig. 1.)

The fructification of *Calamites* was long ago supposed by Ettingshausen and others to be the same as *Volkmannia*; and the great number of small cones, evidently nearly

allied to the latter genus, found lying around my specimens, pointed out the probability of such being the case, when they first came before me; but it was only when the structure of their central axis was examined and found to be of the same character as the stem of *Calamodendron* that the connection of the one with the other was clearly established.

Plate IV, fig. 1, represents a transverse section of Specimen No. 5, one of the cones, $\frac{1}{10}$th of an inch in diameter, magnified forty-five times. It shows the central axis of the column, composed of hexagonal and pentagonal tubes, which have been somewhat displaced from their original position. Around the part last described is a space where the structure is not shown; and then comes a six-sided girdle of rather larger tubes, giving rise to bundles of pseudo-vascular tubes (enveloped in cellular tissue), which constitute the thick portion of the disc-like scale, which divides the cone into receptacles, or cells, containing the sporangia, and from which the leaves proceed and go upwards. These sporangia (marked *j j*) are of an irregular oval shape, having the broader ends near the periphery and the narrower next the central axis. They were arranged in series of fours, around a stout spike, as described by Ludwig. In this transverse section, of course, only two are shown, and they appear to have been enveloped in a bladder-shaped bag, traces of which are seen in the dark curved lines (marked *kk*) bounding the four best preserved sporangia, shown in the lowest part of the figure, and which, when in a perfect state, would in a transverse section have presented a cordate form.

In this specimen distinct evidence of six of these bags, each containing twelve sporangia, is shown instead of the five containing ten sporangia in Ludwig's figure. The outer coating of the sporangium is composed of a single row of cells, and the sporangium itself is full of round bodies, like microscopic spores, some of which have an appearance of a triradiate ridge on their outsides, but the majority appear plain, as represented in the figure. The section seems to have been made across the cone midway betwixt the base of the scale forming the cell-partition, and the spike or spine supporting the sporangia, and therefore affords little evidence of the structure of either of those parts of the cone. For this we must resort to the longitudinal sections contained in Plate V, which will afford us the requisite information.

§ 5. The Specimen (Cone of *Calamodendron commune*) No. 6.
(Plate 4, fig. 2.)

Plate IV, fig. 2, represents a transverse section of No. 6, ($\frac{1}{12}$th of an inch in diameter, magnified 54 times), another cone, similar to that last described. This has the walls of its sporangia considerably disarranged, and only a few spore-like bodies are scattered about the section. The central axis is in a fair state of preservation, and is composed of a mass of hexagonal and pentagonal tubes, smaller in size than those shown in fig. 1, but like them in other respects. A space without structure then intervenes between the

axis and an irregular zone of larger tubes, from which zone project six angular arms, that appear to me to be transverse sections of six of the processes which support the sporangia, and which it will be well hereafter to term "sporangium-bearers." These seem to have been composed of tubes, having something of a pseudo-vascular character; and the lowest one in the figure appears to join with the outside covering of the bladder or bag (*k k*) containing the sporangia; but of this we cannot be certain, as the parts of the specimen are much disarranged.

These two transverse sections (Pl. IV, figs. 1 and 2), which are the best preserved amongst many in my collection, afford us evidence that the central axis or column of the cone was composed of hexagonal and pentagonal tubes, surrounded by a substance which has left no evidence of its structure, and outside this is the zone of hexagonal coarser tubes from which spring six heart-shaped bags or bladders containing the upper twelve of twenty-four sporangia, similar to those described by Ludwig, except that their number is two more than were seen in his specimen.

§ 6. Description of Specimens (Cones of *Calamodendron commune*) Nos. 7—11. Plate V, figs. 1—5.

Plate V, figs. 1, 2, 3, 4, 5, 5*a*, and 5*b* represent the specimens, Nos. 7, 8, 9, 10, and 11, and are longitudinal sections of small cones similar to those (Nos. 5 and 6) of which transverse sections are given in Plate IV, and described at pages 23 and 24.

Fig. 1 (No. 7) represents a specimen one third of an inch in length, and magnified thirteen and a half diameters. It shows seven receptacles, or cells for sporangia; and more may have existed in the original specimen, as the extremities of the cone are probably wanting in the section. The bases or pedicles of the scales belonging to the second and third receptacles (from the top) are seen to proceed on each side from the central axis, and appear to consist of tubes or utricles, whilst the other divisions or floors, four in number, which are cut outside the central axis, are concavo-convex, and appear to be composed of a thick band of cells, whence spring the stout, fleshy, outside scales or leaves, which take a vertical direction, and enclose each receptacle until the bottom of the next scale or leaf is reached. In each receptacle is seen evidence of sporangium-bearers, one opposite the other, springing from the central axis. In the uppermost chamber is a tangential section of one; in the 2nd, a similar section of two; in the 3rd, a longitudinal section of two, which are seen to proceed from the central axis; the 4th, a tangential section of two; the same in the 5th. In the 6th is a tangential section showing four sporangia grouped round a sporangium-bearer; and this affords us distinct evidence of the quadrate arrangement of the sporangia around the "bearer," as first noticed by Ludwig. In the 7th and last receptacle, shown only on the outside of the central axis, no evidence of a longitudinal section of a sporangium-bearer is seen, but a part of one and larger portions of the terminal parts of four other scales or leaves are shown.

4

Most of the sporangia in this cone are disarranged, or their sections are such as not to give us a good idea of their original form; but they are all full of sporelike bodies.

Fig. 2 (No. 8) is a cone rather less than one third of an inch in length, magnified fourteen diameters. It gives evidence of eight receptacles (all holding sporangia, more or less disarranged and containing a few spores), eight sets of scales or leaves, and sporangium-bearers, both in tangential and longitudinal sections, as follow:—in each of the first four receptacles, going downwards from the top, are two tangential sections: in the 5th, two longitudinal sections and one tangential: in the 6th, one longitudinal and one tangential section: in the 7th are two longitudinal sections, showing portions of the sporangium-bearers, connected with the central axis of the cone: in the 8th, there are no remains of the sporangium-bearers; but a portion of the base of a scale and the whole of the terminal part of that organ are visible.

In this figure, although the section only shows a portion of the column, the form of the scales and leaves forming the receptacles is well shown in the lower part. This specimen in all respects so exactly resembles that of fig. 1, that it requires no further description.

Fig. 3 (No. 9), magnified nineteen diameters, is a tangential section of a single receptacle, and shows four sporangia, of a cordate form, two of them being full of dark-coloured sporelike bodies. The outsides of these sporangia appear to be thicker and darker in colour than the generality of the specimens. Probably these differences may arise from the sporangia being in a younger stage of growth. The section is outside the central axis, and near to the ends of the sporangia. These dark sporelike bodies are frequently met with, in a detached state, in the nodules; but they are not often found in their position in the receptacle as seen in this case. The sporelike bodies also appear to be larger in size than those commonly met with in ordinary sporangia.

Fig. 4 (No. 10), magnified twenty-four diameters, represents a longitudinal section of little more than a single receptacle of a cone, but it clearly shows the marked difference of the scales, both in form and structure, to the sporangium-bearers. The thick fleshy bases or pedicles of the scales appear to have formed a disc- or cup-shaped division between the receptacles, and to have been composed of coarse cellular tissue on the outside, enveloping a bundle of pseudo-vascular tissue, which was prolonged into the apex of the scale or leaf. The sporangium-bearers are broad at their point of connection with the central axis, but they soon taper off, and form a spindle-shaped process like a thorn or spine, chiefly composed of pseudo-vascular structure. Some of the sporangia contain few sporelike bodies, and some are entirely empty.

Fig. 5 (No. 11), magnified eighteen diameters, represents the most perfect longitudinal section of a cone that has yet come under my observation. In it we find the structure of the central axis to be of the same character as that of the pseudo-vascular bundles in *Calamodendron* (see p. 20 and 23), both being composed of tubes that have their walls perforated with oval openings. A portion of this structure, magnified 130 diameters, is shown

in fig. 5*b*, and will be at once recognised by all who have investigated the microscopical characters of coal, as frequently occurring in the charcoal or "mother-coal," and which, as far as I know, has never been clearly traced to any particular fossil plant. This specimen also affords evidence of the thick scales, or divisions of the receptacles, with their leaflike ends, and of the sporangium-bearers, all in their natural positions, connected with the central axis, and not separated and disarranged, as most generally met with. A highly enlarged sporangium (magnified forty-five diameters) full of sporelike bodies, taken from this specimen is given in fig. 5*a*.

The structure of the central axis of the cone, as seen in fig. 5, and as previously shown in specimens Nos. 5 and 6, Pl. IV, figs. 1 and 2 (p. 23, &c.), appears to have had its middle composed of tubes having a pseudo-vascular structure, surrounded by a zone of something which has not been preserved, and now shown by a blank space in the specimen. Next comes a zone of larger-sized tubes, of a hexagonal form, from which spring the receptacle divisions (or scales and leaves), and the sporangium-bearers.

§ 7. Description of Specimens Nos. 12, 13, 14, 15, and 16. [Plate VI.]

In the strata near where the nodules containing the fossil wood showing structure occurred no specimens of *Asterophyllites* or of the fructification of that genus of plants were found except those previously described; but in my cabinet are three specimens, from the Carboniferous strata, of the fructification of plants most probably allied to *Calamodendron*, which are worth describing. In all their characters, but more especially as regards size and shape, they bear great resemblance to the specimens of fructification before mentioned. Unfortunately none of them afford any evidence of internal structure; we get only an outside view of the sporangia, and see nothing of their internal parts or contents, as we see in my specimens from the coal-seams.

Plate VI, fig. 1 (No. 12), represents a stout stem, having traces of ribs and furrows, and seven joints, at which knots appear. From these last-named parts, on each side of the stem, are seen to proceed seven cones, each about half an inch in length, springing outwards in a nearly horizontal direction in the specimen. These cones do not expose any trace of a central axis; but are composed of crown-shaped masses, most probably of sporangia, contained in receptacles, arranged around an axis. Eight or nine of these can be seen in one cone. Unfortunately the specimen being in soft shale, no evidence can be obtained of its internal structure, so as to ascertain if the sporangia contained any spores. If it is not the same as Dr. Goeppert's *Aphyllostachys Jugleriana*,[1] it is very closely allied to that plant.

[1] 'Ueber Aphyllostachys, eine neue fossile Pflanzengattung aus der Gruppe der Calamarien, so wie

As previously stated, I am indebted to my friend Mr. John Aitken for the specimen which I believe was found by Mr. H. Stephenson, near the lowest Brooksbottom Coal, at Ewood Bridge, Lancashire, about fourteen yards below the position of the greater number of the specimens described in this memoir, and near the seam of coal marked * in the vertical section of the Lancashire Coal-field previously given (p. 12). The only point in which this specimen appears to differ from Ludwig's (see above, p. 5), is that it only possesses eight to nine receptacles or cells, against his fifteen to sixteen.

Another specimen of the fructification of a plant evidently allied to *Asterophyllites* and *Calamodendron* is given in Plate VI, fig. 2 (No. 13), magnified half as large again as the original. This consists of a stout stem, finely ribbed and furrowed, and affording evidence of four sets of fruit-cones, springing upwards at a high angle from four joints of the stem. Although only four cones are seen at each joint, more may be underneath, covered up in the matrix. In two of those sets which are more perfect than the rest we observe traces of four cones, and in the other only two. Each cone has a central axis or column, from which spring ten scales on a side, forming receptacles or sporangium cases, similar to those described in Pl. VI, fig. 1 (p. 27), except that there we only see eight on each side. In this specimen we do not find the terminal point of the cone, so that there is no positive evidence of the number of scales it originally possessed.

In size and characters, especially as to its stem, this specimen bears considerable resemblance to the *Volkmannia sessilis*, of Presl, figured by Dr. Goeppert,[1] as well as to the fructification of *Calamodendron*; and although probably the evidence may not be sufficient clearly to connect either this or the last-described specimen specifically with the *Calamodendron commune* figured by me, still they must be considered as nearly allied to it, as well as to Ludwig's specimen (see above, p. 5), and they are valuable in showing the connection of the cones with the stems on which they grew.

In the Upper Coal-measures of Ardwick, near Manchester, above the highest seam of coal there met with, is an abundance of *Calamites* and *Asterophyllites*, especially the species *A. longifolia*, of Lindley and Hutton; and connected with the latter plant, and lying around both, are numerous fruit-cones, which, although showing no structure (being embedded in a liver-coloured shale), give a clear idea of their external form, and the mode by which they were connected with the stem and leaves of *Asterophyllites*.

Pl. VI, fig. 3 (No. 14), represents a specimen of *Asterophyllites longifolia* (from Ardwick) in my cabinet, magnified half as large again as its natural size. Springing from the stem, at each of the joints, twelve to fourteen verticillate leaves are shown in the part of the specimen exposed, and probably as many more may be concealed on the other side

über das Verhältniss der fossilen Flora zu Darwin's Transmutations-Theorie;' von Dr. H. R. Goeppert, Dresden, 1864.

[1] See Goeppert on 'Aphyllostachys,' *antè*.

in the matrix. Some of these leaves measure nearly an inch and a half in length, and are marked with a keel. Altogether, in form and character (except being a little less in size), those leaves bear great resemblance to *Lepidophyllum.*

In Pl. VI, fig. 4 (No. 15), is another specimen from Ardwick (magnified twice its natural size), having a stem of about two inches in length, and not so stout as the two last described, but more deeply furrowed and more sharply ribbed. At each of the joints of the stem (two of which are visible) are seen four fruit-cones, accompanied by as many leaves of *Asterophyllites longifolia*, springing outwards; and probably as many more may be concealed in the matrix underneath.

The cones consist of a central axis, on either side of which, exactly opposite each other, are seen seven or eight pairs of cordate bodies, each having a division in its middle. This organ somewhat resembles the bladder-shaped bag or envelope, containing sporangia, described by Ludwig (see above, p. 24). They are bounded by a scale or disc, coming at first from the axis nearly at right angles, but afterwards running almost parallel to it, and forming the receptacle or sporangium-cases.

In three of these cones is the termination of the scales; and there are six cones seen, probably as many more lying underneath in the shale: thus it is probable that each receptacle had six bags, containing four sporangia each; or altogether twenty-four, as in the specimens showing structure previously described (p. 24). The thorn or spindle, around which the sporangia are fixed, is not well shown unless we take the dark line of division of the sporangium-case to be it. The whole of the specimen so far as the cone is concerned, in its external characters, resembles my other specimens of the fructification of *Calamodendron commune* rather than Ludwig's specimens; and it is found, we must remember, not only with the leaves of *Asterophyllites*, connected with the stem on which it grew, but surrounded by an abundance of detached leaves and stems of that plant.

Pl. VI, fig. 4 *a* (No. 16), represents the apex of a cone, from Ardwick, magnified three diameters; and shows six leaves or scales on the side of the specimen which is exposed to view.

IV. Concluding Remarks.

After the description of the specimens of *Calamodendron* in this Monograph, it will not be out of place to notice the points in which this genus of plants differs from *Sigillaria*, especially from the plant which I have described as *Sigillaria vascularis*.[1]

The form of the roots of *Sigillaria* varies from that of *Calamodendron*. It is true that the termination of *Stigmaria* is club-shaped, like that of *Calamodendron*, and the rootlets are arranged in quincuncial order, as was shown in the paper of mine previously alluded to (see above, p. 15); but in the latter plant we find no trace of the regular bifurcation of the main and lesser roots; and the roots appear to have been small in size, with regard to the stem and branches of the plant, when compared with similar parts in *Sigillaria*. From all the evidence which has been obtained by me, *Calamodendron* must have been a plant of small size when compared with *Sigillaria*.

The largest *Calamodendron* that has come under my notice is one from the Middle Coal-measures, and was found by the late Mr. John Atkinson, F.G.S., in the neighbourhood of Chesterfield; it is now in my possession. The cast of the central axis of this specimen is five and a half inches in diameter; and, taking the proportions of smaller specimens, the woody cylinder, exclusive of the bark, would probably be about one foot in diameter; a small size, when compared with some stems of *Sigillaria*, which have been found to measure seven feet in diameter at the base.

The terminal branches of *Calamodendron* were also of small size, some of them not being more than $\frac{6}{100}$ths of an inch in diameter; whereas the smallest specimens of *Sigillaria vascularis*, which have come under my notice have been about half an inch across; and the branches, like the roots before mentioned, in *Calamodendron* have none of the dichotomous characters so distinctly shown in *Sigillaria vascularis*.

The organs of fructification did not reach more than one third of an inch in length, and were of a diminutive size even when compared with the small bulk of the plant. We cannot well compare them with similar parts of *Sigillaria*, as at present we are unable to speak with absolute certainty as to the fructification of that plant, which was most probably a cone much larger than that of *Calamodendron*. Indeed the small size of the organs of fructification in *Calamodendron* is one of the most singular characters of the plant.

There is a difference also observed in the bundles of vessels passing from the centre to the circumference, dividing the wedge-shaped masses of pseudo-vascular tissue, and which M. Adolphe Brongniart and some other authors considered to be of the nature of

[1] 'Quart. Journ. Geol. Soc.,' vol. xviii, p. 106, pl. IV and V.

medullary rays, but which Mr. Carruthers, with apparently very good reasons, regards as not having that character in *S. vascularis*. At the joints, where the branches spring from the stem, the bundles of vessels there found much resemble those of *S. vascularis;* but the tissue dividing the pseudo-vascular bundles in *Calamodendron* is very different; and, when seen in the small openings towards the outer part of the woody cylinder, has more the appearance of a medullary bundle (being formed of cellular tissue) than those found in *Sigillaria vascularis,* which are barred on all their sides, like the tubes formiug the woody cylinder of that plant.

Although some years since it occurred to me, as well as to others, that small *Calamodendron* might possibly have been young *Sigillaria,* judging only from the rootlets and some other portions of the plants, still we have seen that in the external characters of the two genera there is no evidence to establish their identity. When also we come to compare the internal structure of the two plants, one differs from the other so much as to dispose of any outward resemblance. In *Sigillaria*, whether we take *Diploxylon cycadoideum* or *Sigillaria vascularis,* there are two woody cylinders, formed of radiating tissues, while in *Calamodendron* there is only one such woody cylinder. The tubes composing the internal radiating cylinders in the two first-named plants have their walls covered with fine horizontal lines or striæ, either free or anastomising; while in the last-named plant the walls of the tubes are much thicker, and are pierced by oval openings, having their major axes at right angles to the direction of the tubes. In addition, the central axis in *Sigillaria* has no horizontal diaphragms dividing it into separate portions, as is the case in *Calamodendron,* although the casts of the two central axes are each striated longitudinally.

From the examination of the specimens described in this Monograph, *Sigillaria* and *Calamodendron* must be considered as two distinct plants, although they doubtless grew in similar positions, and in their habitats accompanied each other, in greater or less abundance, during the whole of the time in which the Carboniferous strata were in the course of formation, as is evident from the remains of both plants being so frequently found associated together in the "mother-coal" of this and other countries.

In the upper seam of coal in the section of the strata previously given (p. 12), and there marked with a single asterisk, *Calamodendron* is by far the most common plant, and *Sigillaria* (in the form of *Diploxylon cycadoideum*) is but rarely found; while in the seams marked with two and three asterisks, higher up in the series, *Sigillaria vascularis* is by far the commonest form, and *Calamodendron* is rarely met with; *Calamodendron* being the smaller plant, forming the chief part of the small seam of coal, and *Sigillaria* the larger plant, forming the greater proportion of the thicker seam of coal. Something similar occurs in the Upper Coal-measures of Ardwick, whence the specimens Nos. 14 and 15 came. *Calamites,* then, is one of the most common plants met with, and it is found associated with *Asterophyllites*, *Lepidodendron*, *Lepidostrobus,* and *Lepidophyllum*, but with no traces of large-ribbed and furrowed *Sigillaria*, and only rare specimens of *Sigillaria*

elegans. In this locality no seam of coal is found associated with the fossil plants; and a small bed, a few inches in thickness, occurs about fifty feet below them. My observations on this part of the subject have been made chiefly whilst searching for specimens affording evidence of structure, and not over any great thickness of the strata, and therefore further attention should be devoted to it in order to determine whether or no this condition occurs throughout the Coal-measures where *Sigillaria* and *Calamites* are found associated. Many years since, when examining the thick seams of coal which are found in the middle division of the Lancashire Coal-field, I noticed the occurrence of large-ribbed and furrowed *Sigillariæ*, and I stated in a paper on the Origin of Coal, read before the British Association in 1843, and printed in the Report of the Association's first Meeting at Manchester, that where such large specimens occurred not only were the seams of coal thick, but they were open-burning coals, leaving a white ash. Many years' observation on this subject has confirmed my first impression. Of course it is not contended that ribbed and furrowed *Sigillariæ* are not to be met with from the lowest to the highest Carboniferous strata and their roots (*Stigmariæ*) found in coal-floors throughout, but it is merely intended to state that during the formation of the thick seams of the Middle Coal-measures greater crops of these trees prevailed, and produced more mineral ingredients to form the white ash, as well as the thicker seams of coal.

NOTE.—The Author thinks it necessary to state that the Specimens described in this Memoir were discovered twelve years ago, and some of them immediately "mounted" and sent to Dr. Hooker, who had consented to join in publishing a description of them. With the specimens was written, November 29th, 1854, "You will be delighted to find such beautiful sections of *Volkmannia* in the large slide I now send. "They are well worth the trouble and expense of the slide. These, doubtless, belong to *Calamites*." Soon afterwards the Author had the opportunity of pointing out under the microscope the spore-like bodies in the sporangia to Dr. Hooker.

At that time the whole of the structure of *Calamodendron* had been made out, with the exception of the centre of the stem and the connection of *Volkmannia* with it. The valuable paper of Dr. Ludwig on the Calamite fruit, and Dr. Goeppert's on *Aphyllostachys*, afforded the writer much information; and he obtained the evidence of *Volkmannia* being the fruit of *Calamodendron* from the similarity of the central axes. About two years since he cleared up both the above points to his satisfaction, but Dr. Hooker had returned the specimens, and was prevented by press of business from joining him in publishing. The author then commenced the present Memoir unaided, and the plates were put in the engraver's hand. Owing to circumstances over which he had no control, the publication of the Memoir has been delayed longer than he expected.

In the mean time, in Memoirs referred to at page 10, Mr. Carruthers has described the Calamite and its fruit mainly from some of the Author's specimens above mentioned, which Dr. Hooker had lent him with others. The published observations are, of course, independent of each other; and, whatever may be their relative value, the Author wishes the dates and history of the specimens and investigations to be clearly stated.—E. W. B.—January 30th, 1868.

PLATE I.

Calamodendron commune.

Fig. 1 (No. 1). A decorticated specimen from the Upper Brooksbottom Seam of Coal, Lancashire. Natural size.

Fig. 2 (No. 2). The furrowed and ribbed cast of the central axis of a large specimen from the same locality as No. 1. Natural size.

In the following Plates the same parts in the specimens figured are indicated by the same letters, as follow:

a a. The middle part, showing the central axis, or pith, composed of large hexagonal utricles.

b b. The pseudo-vascular cylinder, composed of quadrangular tubes, having all their sides perforated by oval openings; they are arranged in wedge-like bundles and in radiating series, originating from "orifices" near the thin end of the wedge next the central axis, increasing in size as they approach the circumference, and divided by medullary (?) bundles.

c c. Wedge-shaped masses of lax tissue, composed of oblong cells, in radiating series, having the thick end of the wedge next the central axis. Both wedges and cells increase in size in the opposite direction to that seen in the tubes and masses of the pseudo-vascular cylinder, *b b.*

d. Diaphragm, apparently composed of cellular tissue, dividing the central axis or pith horizontally at the Joints.

e e. Oval-shaped bundles of pseudo-vascular tissue, passing from the central axis, or pith, and communicating with the Leaves.

f f. Bundles of cellular tissue, of an elongated oval form, near the circumference of the stem, dividing the pseudo-vascular cylinder, and having the appearance of medullary bundles, though only extensions of the wedge-shaped masses, *c c.*

g g. The central axis or column of a Cone.

h h. The Scales or Leaves forming the divisions of the Sporangium-receptacles or cells of a Cone.

i i. The Sporangium-bearers of a Cone.

j j. Sporangia full of Spore-like bodies.

k k. Portions of the bag containing the Sporangia.

Plate 1

Fig. 1

No 1

Fig 2

No 2

J. N. Fitch del. et lith

R. Fitch, imp

PLATE II.

Calamodendron commune.

Fig. 1. Transverse section of Specimen No. 1. Natural size.

Fig. 2. A portion of the transverse section of the same specimen, showing parts of two wedge-shaped bundles of pseudo-vascular tissue, originating at two "orifices" on the outside of the central axis, and parts of the three wedge-shaped masses of coarse tissue, arranged in radiating series. Magnified 10 diameters.

Fig. 3. A longitudinal section of the same specimen, showing the walls of the tubes forming the pseudo-vascular cylinder perforated by elongate-oval openings; taken near to the central axis. Magnified 70 diameters.

Fig. 4. A tangential section similar to the last, taken nearer to the outside of the specimen, showing the oval openings on the walls of the tubes. Magnified 70 diameters.

Fig. 5. A tangential section of No. 1 Specimen, taken near the central axis, showing the pseudo-vascular bundles and the lax tissue dividing them. Magnified 15 diameters.

Fig. 6. A section similar to the last, taken near the middle of the specimen. Magnified 40 diameters.

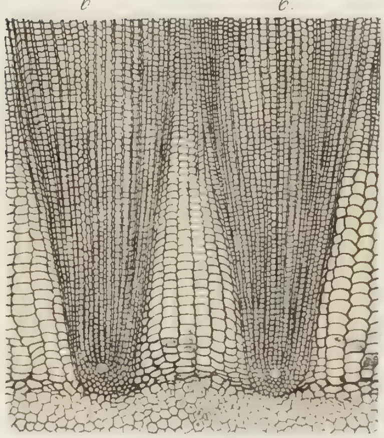
Fig. 1.

No 1

Fig. 4.

No 1

Fig. 2.



No 1.

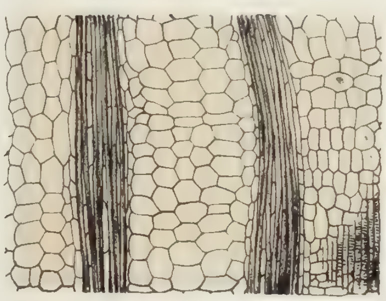
Fig. 3.

No 1.

Fig. 6.

No 1

Fig. 5.



No 1.

J N Fitch, del. et lith. R. Fitch, imp.

PLATE III.

Calamodendron commune.

Fig. 1. Specimen No. 3, from the "Hard Seam" of Coal at South Owram, near Halifax; showing the outside of a decorticated plant, of small size, with ribs, furrows, and a joint. Magnified 2 diameters.

Fig. 2. Transverse section of the same specimen, showing the wedge-shaped bundles of pseudo-vascular tissue, originating from "orifices" and parted by lax tissue. The central axis has for the most part disappeared. Magnified 10 diameters.

Fig. 3. A longitudinal section of the same stem, showing one of the horizontal diaphragms. Magnified 7 diameters.

Fig. 4. A tangential section of the same specimen, showing three oval-shaped bundles of vessels found at the joint, as well as some elongated oval masses of cellular tissue, not unlike medullary bundles. Magnified 12 diameters.

Fig. 5. A longitudinal section of a portion of the same specimen, showing the oval openings on the walls of the tubes forming the pseudo-vascular cylinder. Magnified 50 diameters.

Fig. 6. A tangential section of the same specimen, showing one of the medullary (?) bundles. Magnified 45 diameters.

Fig. 7. Transverse section of a very young stem (Specimen No. 4), slightly compressed, showing the structure of the central axis, the wedge-shaped bundles of pseudo-vascular tissue originating from "orifices," and parted by coarse tissue. From the Upper Brooksbottom Seam of Coal. Magnified 34 diameters.

J N Fitch del et lith

R Fitch imp

PLATE IV.

Calamodendron commune.

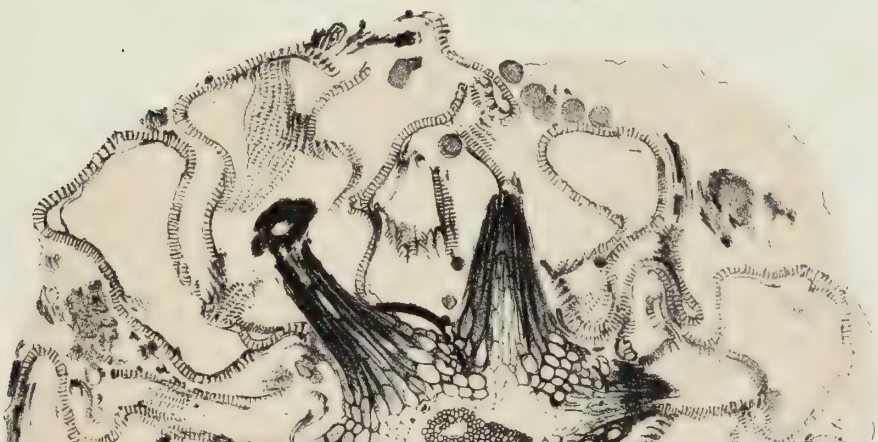
The specimens in this Plate are from the Upper Brooksbottom Seam of Coal.

Fig. 1 (No. 5). Transverse section of one of the Cones or organs of fructification, showing the central axis, composed of hexagonal and pentagonal vessels, and twelve Sporangia, full of Spore-like bodies; the four of the lower ones enclosed in two cordate bags. Magnified 45 diameters.

Fig. 2 (No. 6). Transverse section of another Cone, showing the central axis and six processes or spines (Sporangium-bearers) radiating therefrom, and disarranged Spore-cases, formerly connected with them. Magnified 56 diameters.

Fig. 1.

Fig. 2.



J. N. Fitch, del. et lith.

R. Fitch, imp.

PLATE V.

Calamodendron commune.

All the specimens in this Plate are from the Upper Brooksbottom Seam of Coal.

Fig. 1 (No. 7). Longitudinal section of a Cone, showing seven Receptacles, Scales, and Sporangium-bearers, connected with the column or central axis, and Sporangia full of Spore-like bodies. Magnified $13\frac{1}{2}$ diameters.

Fig. 2 (No. 8). Longitudinal section of a Cone similar to the last, showing eight Receptacles and Sporangium-bearers, connected with the column or central axis, and Sporangia containing Spore-like bodies. Magnified 14 diameters.

Fig. 3 (No. 9). Longitudinal section of a single Receptacle with its two scales; and a tangential section of four cordate Sporangia, two of them containing dark coloured Spore-like bodies. Magnified 19 diameters.

Fig. 4 (No. 10). A longitudinal section of part of another Cone, showing the structure of the Scales and Sporangium-bearers, and the connection of both those parts with the column or central axis. Magnified 24 diameters.

Fig. 5 (No. 11). A longitudinal section of part of another Cone, showing the Scales and Sporangium-bearers, connected with the central axis or column, and the Sporangia, in their natural position, full of Spore-like bodies. Magnified 18 diameters.

Fig. 5*a* (No. 11). A longitudinal section of a single Sporangium full of Spore-like bodies, taken from No. 11 Specimen.

Fig. 5*b* (No. 11). A longitudinal section of a portion of the central axis or column of No. 11, showing the oval openings in the walls of the tubes. Magnified 130 diameters.

Fig 5.ª

Nº11.

Fig. 5.ᵇ

Nº11.

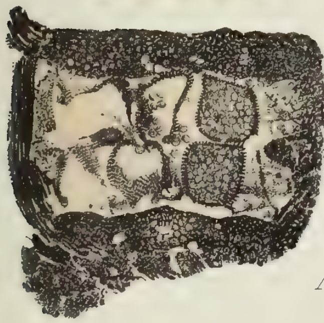


Fig 3.

Nº9.

Fig 1.

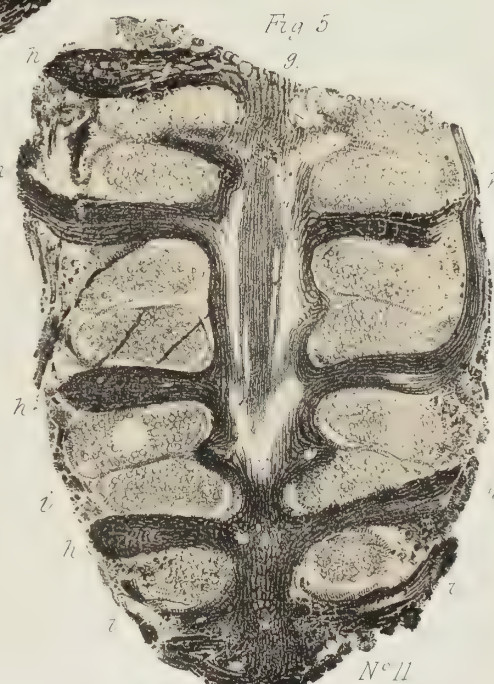
Nº7

Fig 2.

Nº8

Fig 4.

Fig 5



J. N. Fitch, del. et lith.

R. Fitch, imp.

PLATE VI.

Fig. 1 (No. 12). Fruit-stalk, with Cones attached, resembling the *Aphyllostachys Jugleriana* of Goeppert; from the strata adjoining the Lower Brooksbottom Seam of Coal, at Ewood Bridge, Lancashire. Magnified half as large again as the original.

Fig. 2 (No. 13). Fruit-stalk, with Cones attached, resembling *Volkmannia sessilis* of Presl; from the Mountain-limestone at Holywell, North Wales. Magnified half as large again as the original.

Fig. 3 (No. 14). Specimen of *Asterophyllites longifolia*, from the Upper Coal-measures at Ardwick, near Manchester. Magnified half as large again as the original.

Fig. 4 (No. 15). Fruit-stalk of a Plant resembling *Calamodendron commune* (?), with Cones and Leaves attached to it, from the Upper Coal-measures at Ardwick, near Manchester. Magnified twice the natural size.

Fig. 4*a* (No. 16). Specimen showing six Scales, with their apices, attached to the central axis of a Cone, similar to those last described. From the Upper Coal-measures at Ardwick. Magnified 3 diameters.

E. W. B.

Fig 1

N°12

Fig. 2.

N°13

Fig 3.

N°14

4 a

N°16

Fig 4

N°15

J.N Fitch, del et lith.

R. Fitch, imp

A MONOGRAPH

OF THE

BRITISH FOSSIL CORALS.

SECOND SERIES.

BY

P. MARTIN DUNCAN, M.B. LOND., F.G.S.,

SECRETARY TO THE GEOLOGICAL SOCIETY.

Being a Supplement to the

'Monograph of the British Fossil Corals,' by MM. MILNE-EDWARDS *and* JULES HAIME.

PART IV, No. 2.

CORALS FROM THE ZONE OF AMMONITES ANGULATUS (*continued*).

CORALS FROM THE ZONE OF AMMONITES BUCKLANDI, AMMONITES OBTUSUS, AND AMMONITES RARICOSTATUS, OF THE LOWER LIAS.

CORALS FROM THE MIDDLE LIAS; FROM THE ZONES OF AMMONITES JAMESONI AND AMMONITES HENLEYI.

ADDITIONAL SPECIES OF CORALS FROM THE ZONE OF AMMONITES PLANORBIS.

CORALS FROM THE AVICULA-CONTORTA ZONE.

CORALS FROM THE WHITE LIAS.

APPENDIX TO THE LIASSIC CORALS.

INDEX.

Pages 45—73; Plates XII—XVII.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1868.

PRINTED BY J. E. ADLARD, BARTHOLOMEW CLOSE.

CONTENTS.

	PAGE
Description of the Corals from the Zone of Ammonites angulatus *(continued)*	45
Description of the Species	46
On the Corals of the British and European Lower Liassic Deposits of the Zones of Ammonites angulatus, Ammonites planorbis, and Avicula contorta	47
List of Species from the Continental Zone of Ammonites angulatus	48
List of Species from the Continental and British Strata of the Zone of Ammonites angulatus	49
Description of Species from the Zone of Ammonites Bucklandi (bisulcatus)	51
List of the Species	55
Description of the Species from the Zone of Ammonites obtusus	56
Description of the Beds which contain the Madreporaria of the Zone of Ammonites raricostatus	57
Description of the Species	58
List of the Species	61
List of the Species from the Zones of the Lower Lias above the Zone of Ammonites angulatus	61
Corals from the Middle Lias: of the Zones of Ammonites Jamesoni and Ammonites Henleyi	62
Enumeration of the British Liassic Species	64
Description and Notice of Species from the Zone of Ammonites planorbis	65
List of Species from the Zone of Ammonites planorbis	66
Notice of the indeterminable Corals of the Avicula contorta Zone and White Lias of the British Isles (Rhætic of Moore)	66
Note on the Age of the Sutton Stone and the Brocastle, &c., Deposits	69
Index to Nos. 1 and 2 of Part IV	72

A MONOGRAPH

OF THE

BRITISH FOSSIL CORALS.

(SECOND SERIES.)

PART IV.—No. 2.

VIII. CORALS FROM THE ZONE OF AMMONITES ANGULATUS.
(*Continued.*)

THERE are some Coralliferous deposits belonging to the Lower Lias at Inkbarrow, at Chadbury, in Worcestershire, and Fladbury, near Evesham, whose exact geological horizon has not been determined. They are low down in the Lower Lias, but their commonest Corals do not identify them with the Coralliferous beds of Brocastle. The genus *Isastræa* is dominant in these localities, and its species are unlike any which have been described. The Corals will not do more than associate these beds on one horizon. There is a great probability, from the presence of small Gasteropoda, whose shells are left in the calices of the Corals, that careful search will yield a sufficient number of fossils to determine whether these deposits are below the Zone of *Ammonites Bucklandi.* Our present knowledge does not justify the association of these *Isastrææ* with the Coral-fauna of the Zone of *Ammonites angulatus.*

The Coralliferous deposits at Abbott's Wood, Harbury, Aston Magna, and Down Hatherly may belong to more than one zone; but, from the association of *Thecosmilia Michelini, Thecosmilia Martini,* and *Septastræa Fromenteli,* the presence of the Zone of *Ammonites angulatus* may be satisfactorily asserted.

There is an *Isastræa* found in the Lower Lias of Lyme Regis, which is said to belong to the Zone of *Ammonites angulatus,* but the mineralization of the specimen and its affinities are sufficiently distinct to associate it with the beds containing *Ammonites Bucklandi.*

IX. Description of the Species.

Section—*APOROSA.*

Family—ASTRÆIDÆ.

Division—Lithophyllaceæ simplices.

Genus—Montlivaltia.

1. Montlivaltia Ruperti, *Duncan*. Pl. XII, figs. 3, 4, 5; Pl. XV, fig. 15.

The corallum is turbinate; it is truncated at the base, and is widest at the calice.

The epitheca is strong, and is marked transversely with ridges, prominent lines, and constrictions; the longitudinal markings are faint, but there is a tendency to split in their direction.

The calice is moderately deep, and is circular in outline.

The septa are crowded, unequal, long, and irregular; the longest are thick internally, and reach so far inwards as to give the appearance of a false columella; all are slightly spined.

There are five cycles of septa, in six systems, and those of the highest orders are small, whilst the primary and secondary are equal and very long.

The wall is thick, and the epitheca does not project upwards as a ridge around the circular margin. The endotheca is abundant.

The costæ are small, and are rarely visible beneath the epitheca.

Height of the corallum $\frac{5}{10}$ths inch.

Breadth of the calice $\frac{7}{10}$ths inch.

Locality. Down Hatherly.

In the Collection of R. Tomes, Esq.

Division—Astræaceæ.

Genus—Isastræa.

1. Isastræa Tomesii, *Duncan*. Pl. XV, fig. 20.

The corallum is massive, large, and irregular in shape. The upper surface is subgibbous.

The calices are irregular in size, are separated by very thin walls, and are rather deep and polygonal, quadrangular, or more or less circular.

The septa are very thin, and are faintly dentate; they often curve and unite. They reach well into the axial space, and are united by dissepiments. They are subequal, but many rudimentary septa exist. There are not four complete cycles of septa.

Diameter of calices $\frac{2}{10}$ths—$\frac{4}{10}$ths inch.

Locality. Long Coppice, near Binton, Warwickshire.

In the Collection of R. Tomes, Esq.

The delicacy and subequal character of the septa, their deficiency in decided dentations, and the dissepiments between the septa, characterise this species.

There is an immense *Isastræa* at Inkbarrow, with small calices and thick walls; unfortunately it is not determinable specifically, but the honeycomb appearance and subgibbous upper surface, and the low septal number, may distinguish it. A specimen is in the collection of the Rev. P. B. Brodie, F.G.S.

Isastræa Murchisoni, Wright, is found attached to the Inkbarrow specimen, and thus this Scottish Coral has also an English habitat.

X. On the Corals of the British and European Lower Liassic Deposits of the Zones of Ammonites angulatus, Ammonites planorbis, and Avicula contorta.

The strata of the Lower Lias evidently contain more than one Coral-fauna, and there is a strong distinction between the assemblage of species of the Zone of *Ammonites Bucklandi* and those of the zones below. The Corals of the White Lias are few in number, and probably belong to the genus *Montlivaltia*, but they cannot be distinguished specifically. The *Avicula contorta* series of France and England are uncoralliferous, but the Italian beds at Azzarola, which probably are on that horizon, contain a very remarkable Coral-fauna.

The extent of the area of Coralliferous beds described by Stoppani as the Azzarola series is very considerable. The "Madrepore-bed," as it is termed by Stoppani, is seen above the Azzarola beds, with *Cardium Rhæticum*, *Myophoria inflata*, *Mytilus psilonoti*, *Avicula contorta*, *Terebratula gregaria*, &c., wherever the succession of the rocks can be made out, either on the south-eastern slopes of the Alps, as on the Lake of Como, or on the north-western slopes to the south of the Lake of Geneva.[1] The Madrepore-bed is described, moreover, as occurring below and in the midst of the Azzarola beds, and as forming a dense layer of eight to ten yards in thickness. The prevailing Coral is *Rhabdophyllia Langobardica*, Stop., and the genus is represented by three other species. The *Rhabdophylliæ* resemble in their habit of growth many *Thecosmiliæ*, and form in the Azzarola beds great masses of tangle, like *Thecosmilia Martini* in the Coralliferous beds of the Côte d'Or and of Cowbridge in South Wales. Stoppani describes a *Stylina* from some casts which

[1] Stoppani, 'Monog. des Foss. de l'Azzarola.'

resemble those of *Astrocœnia gibbosa*, nobis, from the Sutton Stone. The species I select as distinguishable in the Azzarola deposits are—

Rhabdophyllia Sellæ, Stopp.
„ *Langobardica*, Stopp.
„ *Meneghini*, Stopp.
„ *De-Filippi*, Stopp.
Montlivaltia Gastaldi, Stopp.
Stylina Savii, Stopp.
Thamnastræa Batarræ, Stopp.
„ *Escheri*, Stopp.
„ *Meriani*, Stopp.
„ *rectilamellosa*, Winkl.

These *Rhabdophylliæ*, *Stylinæ*, and *Thamnastrææ*, are represented in the lowest zones the British Lower Lias by *Thecosmiliæ*, *Rhabdophylliæ*, and *Astrocœniæ*.

The strata between the Trias and the Zone of *Ammonites Bucklandi* in Germany are very uncoralliferous, and the determinations of the species given by Quenstedt are not sufficiently exact. MM. D'Orbigny, Terquem et Piette, and De Fromentel, have noted and described the following species from the Lower Lias, below the Zone of *Ammonites Bucklandi*, *Gryphæa incurva*, &c., in France and Luxembourg, and by omitting *Isastræa basaltiformis*, De From., which belongs to the Zone of *Ammonites planorbis*, the following table will give all the species from the Continental Zone of *Ammonites angulatus*:—

XI. List of Species from the Continental Zone of Ammonites angulatus.

1. *Montlivaltia Sinemuriensis*, D'Orb.
2. „ *dentata*, De From. et Ferry.
3. „ *Martini*, De From.
4. „ *Rhodana*, De From. et Ferry.
5. „ *discoidea*, Terquem et Piette.
6. „ *Haimei*, Chapuis et Dewalque.
7. „ *Guettardi*, Chapuis et Dewalque.
8. „ *polymorpha*, Terquem et Piette.
9. „ *denticulata*, De From. et Ferry.
10. *Thecosmilia Martini*, De From.
11. „ *Michelini*, Terquem et Piette.
12. „ *coronata*, Terquem et Piette.
13. *Septastræa Fromenteli*, Terquem et Piette.

14. *Septastræa excavata,* De From.
15. *Isastræa Condeana,* Chapuis et Dewalque.
16. „ *Sinemuriensis,* De From.
17. *Stylastræa Sinemuriensis,* De From.
18. „ *Martini,* De From.
19. *Astrocœnia Sinemuriensis,* D'Orb.
20. „ *clavellata,* Terquem et Piette.

Probably some of the species of *Montlivaltia* will have to be absorbed by others, but this list, when added to the Table of British Corals from the Zone of *Ammonites angulatus,* proves that, instead of the Lias being an uncoralliferous series, it was quite the contrary. The great development of Coral-life in the Azzarola series, the scanty remains of it in the western and north-western European *Avicula contorta* Zones and in the White Lias and in the Zone of *Ammonites planorbis,* and the luxuriance of the species in the Zone of *Ammonites angulatus,* are very significant facts; and the significance is not diminished when the paucity of the species of the *Ammonites Bucklandi* Zone and their distinctness from those of the Zone of *Ammonites angulatus* is considered.

XII. List of Species of Corals from the Continental and British Strata of the Zone of Ammonites angulatus.

1.	*Oppelismilia gemmans,*	Duncan.	Ireland.
2.	*Montlivaltia Walliæ,*	„	South Wales.
3.	— *Murchisoniæ,*	„	„
4.	— *Ruperti,*	„	England.
5.	— *parasitica,*	„	South Wales.
6.	— *simplex,*	„	„
7.	— *brevis,*	„	„
8.	— *pedunculata,*	„	„
9.	— *polymorpha,*	Terquem et Piette.	South Wales; East of France.
10.	— *Haimei,*	Chapuis et Dewalque.	England; Ireland; Luxembourg; France.
11.	— *Hibernica,*	Duncan.	Ireland.
12.	— *papillata,*	„	England; Ireland.
13.	— *Sinemuriensis,*	D'Orb.	France.
14.	— *dentata,*	De From. et Ferry.	„
15.	— *denticulata,*	„	„
16.	— *Rhodana,*	„	„
17.	— *Martini,*	„	„

18. *Montlivaltia discoidea*, Terquem et Piette.		France.	
19. — *Guettardi*, Blainville.		Luxembourg and England.	
20. *Thecosmilia Suttonensis*, Duncan.		South Wales.	
21. — *mirabilis*,	,,	,,	
22. — *serialis*,	,,	,,	
23. — *irregularis*,	,,	,,	
24. — *Terquemi*,	,,	,,	
25. — *affinis*,	,,	,,	
26. — *dentata*,	,,	,,	
27. — *plana*,	,,	,,	
28. — *Brodiei*,	,,	,,	
29. — *Martini*, E. de From.		South Wales; England; France; Luxembourg.	
30. — *Michelini*, Terquem et Piette.		,, ,, ,, ,,	
31. — *coronata*,	,,	France	
32. — *rugosa*, Laube.		South Wales; St. Cassian.	
33. *Rhabdophyllia recondita*,	,,	,,	,,
34. *Astrocœnia Sinemuriensis*, D'Orb., sp.		South Wales; France.	
35. — *clavellata*, Terquem et Piette.		France.	
36. — *gibbosa*, Duncan.		South Wales; Azzarola?	
37. — *plana*,	,,	,,	
38. — *insignis*,	,,	,,	
39. — *reptans*,	,,	,,	
40. — *parasitica*,	,,	,,	
41. — *pedunculata*,	,,	,,	
42. — *costata*,	,,	,,	
43. — *favoidea*,	,,	,,	
44. — *superba*,	,,	,,	
45. — *dendroidea*,	,,	,,	
46. — *minuta*,	,,	,,	
47. *Cyathocœnia dendroidea*,	,,	,,	
48. — *incrustans*,	,,	,,	
49. — *costata*,	,,	,,	
50. *Elysastræa Fischeri*, Laube.		,,	St. Cassian.
51. — *Moorei*, Duncan.		,,	
52. *Septastræa excavata*, E. de From.		,,	France.
53. — *Fromenteli*, Terquem.		,,	England; Ireland; France.
54. *Stylastræa Sinemuriensis*, E. de From.		,,	
55. — *Martini*,	,,	,,	
56. *Latimæandra denticulata*, Duncan.		,,	

57. *Isastræa Sinemuriensis*, E. de From. South Wales; France.
58. — *Condeana*, Chapuis et Dewalque. Luxembourg; France.
59. — *globosa*, Duncan. South Wales.
60. — *Murchisoni*, Wright. Isle of Skye; Inkbarrow, England.
61. — *Tomesii*, Duncan. Worcestershire.

Of these 61 species 50 are found in the British Isles.

XIII. Corals from the Zone of Ammonites Bucklandi (bisulcatus).

Corals are not numerous in this zone, and the commonest species of the Zone of *Ammonites angulatus* are not found in any of its strata. It is probable that *Thecosmilia Martini*, E. de From., which in France ranges from the beds containing *Ammonites Moreanus* into those in which *Ammonites bisulcatus* is found, has a corresponding vertical distribution in England. *Thecosmilia Michelini*, Terq. et Piette, appears to be present in the Zone of *Ammonites Bucklandi*, but only in the form of casts, which resemble those found at Abbott's Wood, in the Zone of *Ammonites angulatus*. These casts and some of *Thecosmilia Martini* have been assigned to the genus *Cladophyllia*, but without sufficient reason. *Thecosmilia* is a large genus, and the species contain individuals of all sizes, so that to give to very small cylindroid *Thecosmiliæ* the term *Cladophylliæ* is too artificial a distinction. The septa of *Thecosmiliæ* are generally, but by no means universally, regularly toothed, granular, and slightly exsert; and the septa of *Cladophylliæ* are said to be small, not numerous, and slightly dentate; moreover, the endotheca is scanty in *Cladophyllia*, but abundant in *Thecosmilia*. These are not generic distinctions, and it is very probable that one genus will absorb the other.

Section—*APOROSA*.

Family—ASTRÆIDÆ.

Division—Lithophyllaceæ simplices.

Genus—Montlivaltia.

1. Montlivaltia Guettardi, *Blainville*, 1830. Pl. XII, figs. 10—14.

The following is the specific diagnosis given by MM. Chapuis and Dewalque.[1]

Corallum simple and rather variable in shape; often conical, more or less depressed, rarely cylindro-conical; the base is slightly pedicillate.

[1] Chapuis et Dewalque, 'Descript. des Foss. des Terr. Second. du Luxembourg, 1854.'

Epitheca thick, ridged, and extending to the calicular border.

Calice circular, ordinarily concave, shallow.

Septa usually thin, granular; strongly toothed on their arched margins.

Five cycles, the first three nearly equal.

This Coral varies greatly in its height and basal flatness. It may be sub-turbinate, or even discoidal; and the specimen from Bottesford, in Lincolnshire, is flat below and very convex above, but it presents an axial depression. The Continental specimens appear to be found in a lower horizon of the Lias than that in which the specimen figured in Pl. XII was found.

Locality. Bottesford, Lincolnshire.

In the Collection of Rev. T. C. B. Chamberlin, F.G.S.

There are specimens, which I believe are young forms, that were found at Fenny Compton and Aston Magna. Pl. XII, figs. 6 and 7.

There is a microscopic Coral at Willsbridge, in the Lima-series (Pl. XV, fig. 9), but the species is not distinguishable. It is figured, as perhaps a larger form may be discovered. Small and young *Montlivaltiæ* are very common on Gryphææ and on large Corals.

Family—ASTRÆIDÆ.

Division—Faviaceæ.

Genus—Septastræa.

1. Septastræa Eveshami. *Duncan.* Pl. XIII, figs. 5—7.

The corallum is large, tall, and flabelliform, and the surface is subgibbous. The base is small, and the corallites radiate and elongate rapidly.

The calices are very irregular in shape and size, and many are twisted and irregular; all are shallow, and those which are fissiparous are narrow. Some calices are polygonal, but fissiparity can be distinguished in most.

The septa are small, dentate, and very irregular in size and arrangement. There are between thirty and forty septa in regular calices, but in the elongated there are many more. The calicular wall is very thin, but where it has been worn a groove is noticed. The endotheca is rather scanty.

Diameter of a polygonal calice $\frac{2}{10}$ths inch, and of elongated calices from $\frac{1}{10}$th to $\frac{2}{10}$ths inch.

Locality. Evesham.

In the Collection of the Rev. P. B. Brodie, F.G.S.

Division—Astræaceæ.

Genus nov.—Lepidophyllia.

The corallum is compound, and the corallites are joined by their walls. The gemmation is calicular and gives an overlapping appearance both to the sides and the upper part of the corallum.

The epitheca is distinct. There is no columella.

The septa are dentate. The calicular gemmation and Astræacean characters distinguish the genus.

There are two species; one is found at Chadbury, and the other in the Island of Pabba, in the Middle Lias.

1. Lepidophyllia Stricklandi, *Duncan*. Pl. XII, fig. 15.

The corallum is tall, and is composed of two sets of corallites.

The calicular gemmation is very frequent and successive. The calicular margins are sharp and wavy; and they are free, except where the corallites join.

The fossa is deep.

The costæ are distinct.

The epitheca is scanty.

Height of corallum 1 inch. Breadth of calice $\frac{9}{10}$ths inch.

Locality. Chadbury, Worcestershire.

In the Collection of Mrs. Strickland. The specimens were collected by the late Hugh Strickland, F.G.S.

Genus—Isastræa.

1. Isastræa endothecata, *Duncan*. Pl. XII, figs. 17—21.

The corallum is large, and either massive and flat, or tall and arising from a small base.

The calices are very irregular in shape, size, and depth. The largest calices are very deep.

The septa are small, and often wavy. They are not exsert, but are very irregular. They are faintly dentate, wide apart, and project slightly from the calicular wall.

The cyclical arrangement cannot be determined by the number of the septa; there are between four and five cycles. The largest septa reach the floor of the calice, where they join.

The endotheca is greatly developed, and it forms small dissepiments, and others which stretch across the corallites almost like tabulæ.

The marginal gemmation is frequent.

Length of the largest calice $\frac{1}{2}$ inch. Depth $\frac{1}{5}$—$\frac{1}{4}$ inch.

Locality. Lyme Regis.

In the Collection of R. Tomes, Esq.

2. Isastræa insignis, *Duncan.* Pl. XIII, figs. 10, 11.

The corallum is massive and forms a flat mass. The corallites are very equal in size and regular in shape.

The calices are placed very regularly in linear series; they are shallow, open, and are separated by a stout wall. The calices are generally hexagonal, but many are square.

The septa are small, project but slightly from the wall, are dentate and unequal. There are four cycles of septa in six systems in the largest calices. The primary and secondary septa are nearly equal; the tertiary are decidedly smaller, and the rest are the smallest.

The endotheca is close.

There is no columella.

Diameter of largest calices $\frac{3}{10}$ths inch, and of the usual size $\frac{2}{10}$ths inch.

Locality. Lyme Regis.

In the Collection of R. Tomes, Esq.

This is a very well-marked species, and belongs to a section which comprises *Isastræa Henocquei*, Ed. and H., from the Lower Lias of Hettange, *Isastræa polygonalis*, Michelin, sp., of the Muschelkalk, and *Isastræa Lonsdalei*, Ed. and H., of the British Inferior Oolite.

3. Isastræa Stricklandi, *Duncan.* Pl. XIII, figs. 1—4.

The corallum is very tall, has a small base, and is expanded superiorly.

The corallites are unequal in size and length, and vary much in shape.

The calices are very irregular in form and depth; their walls are thick, and the septa stout and very dentate. The dentations are blunted and are very large, and more so internally than near to the calicular margin.

The septal number varies, and 32—40 appear to be the usual number. The laminæ are stout, and the primary and secondary septa reach downwards to the base of the fossa and are dentate. The others, which are short, are also stout.

The endotheca is greatly developed, and consists of small vesicular dissepiments, and of larger masses which stretch across the corallites like tabulæ and close in the calicular fossa.

Height of corallum 6 inches. Breadth of largest calice $\frac{3}{10}$ths inch.

Locality. Chadbury, Evesham.

In Mrs. Strickland's Collection.

Genus—Cyathocœnia.

1. Cyathocœnia globosa, *Duncan*, Pl. XIII, figs. 8, 9.

The corallum is nearly spherical.

The calices are numerous, small, and shallow. They are rarely circular, and are generally rather polygonal in outline, and they are separated by a small amount of cœnenchyma. There are no costæ.

The septa are stout at the wall and taper off inwardly; they are subequal, distant, and form three more or less perfect cycles in six systems.

Diameter of the calices $\frac{1}{10}$th inch.

Locality. Fladbury, in Drift with *Gryphæa incurva*.

In the Collection of R. Tomes, Esq.

The shape of the corallum, the absence of costæ, and the shallow calices, distinguish this species from *Cyathocœnia dendroidea*, nobis, *C. costata*, nobis, and *C. incrustans*, nobis, from Brocastle and the Sutton Stone.

The following analysis of the genus will enable the diagnosis of the species to be determined readily.

Cyathocœniæ with the corallum	branching, having costæ	*C. dendroidea.*
	encrusting, without costæ, cœnenchyma granular	*C. incrustans.*
	flat, having large costæ and a deep calice	*C. costata.*
	globular, without costæ, cœnenchyma plain	*C. globosa.*

XIV. List of Species from the Zone of Ammonites Bucklandi.

1. *Montlivaltia Guettardi*, Blainville.
2. *Septastræa Eveshami*, Duncan.
3. *Lepidophyllia Stricklandi*, ,,
4. *Isastræa endothecata*, ,,
5. ,, *insignis*, ,,
6. ,, *Stricklandi*, ,,
7. *Cyathocœnia globosa*, ,,

XV. Corals from the Zone of Ammonites obtusus, Sow.

Some worn and light-coloured simple Corals of the genus *Montlivaltia* are found at Pebworth, five miles south-west of Stratford-on-Avon, in a bed with *Ammonites Sauzeanus*, D'Orb., and *Ammonites semicostatus.* One of the species (*Montlivaltia mucronata,* Duncan) will be described amongst those of the next zone, in which it is common. The specimens are worn, the calices especially, and all the spines are broken off. The columellary space is occasionally occupied by the prominent ends of the principal septa, the laminæ having been worn away in their middle course. The longitudinal series of costæ are rarely visible, and there are many examples of deformed corallites.

Family—ASTRÆIDÆ.

Division—Lithophyllaceæ simplices.

Genus—Montlivaltia.

1. Montlivaltia patula, *Duncan.* Pl. XV, figs. 6, 7, 8.

The corallum is turbinate, depressed, and slightly longer than broad.

The calice is large, elliptical, very shallow, and open; its margin is sharp, and the wall shelves very gradually inwards, giving to the calice a very open appearance.

The septa are unequal and numerous, and the largest are very long and dentate; the tooth nearest the axial space points inwards and is rounded, and those of the longest septa form an irregular circle around the space. The smallest septa are very rudimentary, but the next in size have, in common with all the others, an internal oval tooth. All the septa are delicate, and they are not crowded. There are five cycles of septa in six systems. The primary, secondary, and tertiary are nearly equal in length. The septa are not exsert, but all are lower than the calicular margin.

Length of the calice $\frac{8}{15}$ths inch. Breadth $\frac{6}{10}$ths inch.

Locality. Walford Hill, Stratford-on-Avon, with *Ammonites semicostatus* and *Ammonites Sauzeanus.* In the Collection of R. Tomes, Esq.

XVI. Corals from the Zone of Ammonites raricostatus, Ziet.

The brick-fields in the vicinity of Cheltenham present dark-coloured clay beds, which have the following succession (see Wright, 'Fossil Oolitic Asteriadæ,' p. 25).

Marle Hill Section.

NO.		FT.	IN.
1.	*Gryphæa-bed;* a hard, ferruginous clay, which broke into fragments, and contained *Gryphæa obliquata*, Sow.	3 to 4	0
2.	*Coral-band;* a thin seam of lightish-coloured unctuous clay, containing a great many small sessile Corals, *Montlivaltia rugosa*, Wright and Duncan, most of which appeared to have been attached to the curved valves of the Gryphææ		1 in. to $1\frac{1}{2}$
3.	*Hippopodium-bed*	10	0
4.	*Ammonite-bed*		?

In Warwickshire the railway-cutting at Honeybourne presented the same beds, and the Coral-band contained a considerable number of the *Montlivaltiæ*.

A section on the line of railway at Fenny Compton, in Oxfordshire, near the station, presents the following beds in descending order; the bed No. 2 is highly coralliferous.[1]

Fenny Compton Section.

NO.		FT.	IN.
1.	White clay, containing *Gryphæa obliquata* (*Maccullochii?*), *G. incurva*, *Belemnites acutus*, *Hippopodium ponderosum*, *Pleurotomaria similis*, &c.	4	0
2.	Blue clay, with included hard blue calcareous bands, containing Corals and the Mollusca mentioned in Bed No. 1	2	0
3.	Blue shale	10	0

Middle Lias clays and shales, with *Ammonites Henleyi*, are superimposed on Bed No. 1; and the blue shale (3) rests on a clay with calcareous masses, the "Cardinia-zone."

The Coral-bands at Marle Hill and Honeybourne are upon the same geological horizon as bed No. 2 of the Fenny Compton section. These beds contain some of the finest specimens of *Montlivaltia* ever discovered.

[1] The Rev. P. B. Brodie, M.A., F.G.S., has given me great assistance, and has furnished me with this section.

Family—ASTRÆIDÆ.

Division—Lithophyllaceæ simplices.

Genus—Montlivaltia.

The *Montlivaltiæ* from Fenny Compton, Honeybourne, and Cheltenham, belong to several species, and two of these are singularly polymorphic. Shape has not very much to do with the specific diagnosis of some recent simple Corals, and it is necessary to assert this in collecting under one fossil species Corals of very diverse external forms. Singularly enough, the Liassic *Montlivaltiæ* from the Zone of *Ammonites raricostatus* are common and are extraordinarily well preserved, although a few years ago a Liassic Coral was excessively rare. Even the ornamentation upon the dentations of the septa is preserved, and the longitudinal striations of the epitheca also. The Fenny Compton Coral-bed contains specimens of the species of all sizes, and this is the case with the deposits containing the so-called *Thecocyathus rugosus,* Wright, at Honeybourne and Cheltenham. At Pebworth the Fenny Compton species are not found in a dark blue matrix, but in a white deposit; moreover, the specimens are usually worn, and they appear to have grown under less favorable conditions than the others.

Thecocyathus rugosus is referable to a group of forms specimens of which are very common; it does not belong, however, to the same family that contains the *Thecocyathi.* Dr. Wright gave the species a name in his MS., but the description and diagnosis have never been published. The Corals have been associated so long with the name of Dr. Wright, that it is just to append his name to the species.

1. Montlivaltia rugosa, *Duncan and Wright.* Pl. XIV, figs. 1, 2, 3; Pl. XV, figs. 14, 16, 17; Pl. XVI, figs. 5—15.

Thecocyathus rugosus, *Wright,* MS.

The corallum is very variable in its shape; it may be tall, conico-cylindrical, and curved, sub-turbinate and curved, short and cylindrical, short and turbinate and curved, or straight. It is pedunculate, and the scar by which it adhered to foreign substances, such as shells, is large and oval, or small and very irregular in shape.

The epitheca is stout and identified with the wall; it is strongly ridged transversely and folded as well as grooved. It is rarely marked by longitudinal lines, and is usually deficient in ornamentation. When the epitheca is worn, the external ends of the septa are seen like costæ, and the oblique external terminations of the endotheca are very apparent, sometimes having a herring-bone pattern. Young corallites are often adherent to the

epitheca, they are therefore not buds, but accidentally attached Corals. When more than one Coral is attached to the same shell the bases appear to join.

The calice is shallow, and its margin is formed by the epitheca, which often intrudes upon its periphery; it is circular or slightly deformed, and it may be either contracted or very open.

The septa are numerous and unequal; they are irregular in size and in their arrangement; they are dentate, and the teeth are regular, rounded above, and ornamented with waving lines and are largest near the axial space. The worn septa show their bases in the form of oval swellings, and when these are of full size the appearance of a columella and pali is simulated. There are four perfect cycles of septa, and the fifth is very irregularly developed, the higher orders being often rudimentary. In some large calices the fifth cycle is complete.

The endotheca is strong and well developed, and its dissepiments are numerous, oblique, and arched.

Height of Coral $1\frac{8}{10}$ths inch, 2 inches, $1\frac{5}{10}$ths inch, $\frac{5}{10}$ths inch.

Breadth of calice $\frac{6}{10}$ths inch, $\frac{8}{10}$ths inch, $\frac{8}{10}$ths inch, $\frac{7}{10}$ths inch.

Locality. Hippopodium-bed and Coral-bed of Marle Hill, Honeybourne, and Fenny Compton.

In the Collections of the Geological Society, British Museum, Dr. Wright, F.G.S., Charles Moore, Esq., F.G.S., R. Tomes, Esq., and Rev. P. B. Brodie, F.G.S.

The ornamentation of the teeth of the septa is very well seen in some specimens, but usually it is worn off and the teeth also. The Coral, although very polymorphic, is very easily distinguished from all others by its septa, epitheca, and base.

2. MONTLIVALTIA MUCRONATA, *Duncan.* Pl. XIV, figs. 4—11 and 14—16; Pl. XV, figs. 10—13.

The corallum is very variable in shape; it has a small peduncle, and a small and more or less circular flat scar. The corallum is turbinate and symmetrical, and widely open at the calice; or more or less compressed and subturbinate; or cylindrical and compressed. When turbinate and with a circular calice, the calice is singularly shallow; but when cylindrical and compressed, or in the young state, the calice is deeper.

The epitheca is strong and rises up with the wall to produce a sharp margin to the calice. The transverse markings are very distinct, and there are constricting ridges and folds. The longitudinal markings are very distinct, ornamental, and symmetrical; they are in groups which are smallest at the base, where they are most distinct and rounded, but they are less distinct at the calice where they are flat. The groups dichotomize, so that there are usually 12 at the base and 24 at the calice; they are separated by well-marked grooves and consist of bundles of longitudinal epitheca swellings and costæ.

The calice is either very shallow and circular, or deep and circular, or deep and

6. *Montlivaltia radiata*, Duncan.
7. *Septastræa Eveshami*, ,,
8. *Lepidophyllia Stricklandi*, ,,
9. *Isastræa endothecata*, ,,
10. — *insignis*, ,,
11. — *Stricklandi*, ,,
12. *Cyathocœnia globosa*, ,,

CORALS FROM THE MIDDLE LIAS.

XIX. Corals from the Zone of Ammonites Jamesoni, Sow.

Dr. Wright notices that this zone is well developed in the Island of Pabba, near Skye, in the Hebrides, and the remarkable Coral about to be described appears to form a bed there of some extent.[1]

Family—ASTRÆACEÆ.

Genus—Lepidophyllia.

1. Lepidophyllia Hebridensis, *Duncan*. Pl. XVI, figs. 1—4.

The corallum is flat, and the corallites are short.

The calices vary in size and number; they are open and shallow, and are crowded with delicate, unequal, and not prominent septa.

The septal arrangement is very irregular. The laminæ are dentate and narrow, and the largest approach the axial space. In calices of ordinary size there are four cycles of septa, and part of a fifth in some systems, whilst in the largest calices the fifth cycle is complete.

The epitheca on the free wall of the corallites, where they overlap those below them in the general imbrication, is smooth. The calicular gemmation occurs centrally, and also near the margin.

Height of the corallum $\frac{8}{10}$ths inch.

Breadth of the calices $\frac{4}{10}$ths—$\frac{6}{10}$ths inch.

Locality. Pabba shale.

In the Collection of the School of Mines, Jermyn Street.

[1] See note 1, page 41, Part IV, No. 1.

XX. Corals from the Zone of Ammonites Henleyi, Sow.

A great number of specimens of all sizes of a very polymorphic *Montlivaltia* have been found on the surface of the fields at Cherrington, near Skipton, and in a water-course or ditch section of the Middle Lias close by. *Ammonites Henleyi*, *Ammonites Chiltensis*, *Cardinia attenuata*, and *Cardinia elongata*, were found with the Corals.

Family—ASTRÆIDÆ.

Division—Lithophyllaceæ simplices.

Genus—Montlivaltia.

1. Montlivaltia Victoriæ, *Duncan*. Pl. XVII, figs. 1—10.

The corallum grows to a great size, and generally presents a scar where it was formerly attached. The shape of the corallum is very variable, and it may be short, turbinate or sub-turbinate, or long and conical, or rudely cylindrical. The corallum is rarely straight, and generally there is a very decided curve in it and a twist also; moreover, there is frequently a constriction just below the calice, and at this point also there is generally a curve.

The calice is either widely open or contracted and small; it is never very deep, but may be characterised either by exsert and rounded septa or by septa which dip at once into a concave fossa. The outline of the calice is usually circular, and slightly compressed. The margin is sharp and is formed by the epitheca.

The septa are numerous, crowded, long, and the principal often extend to and across the axial space, which is rather elongated.

The laminæ are not much thicker at the wall than elsewhere, and the dentation is more distinct close to the wall.

There are six cycles of septa, in six systems, the highest orders being very small.

The epitheca is very dense and is strongly marked with transverse elevations and depressions; where it is worn away, the septal ends are seen, like costæ with transverse dissepiments connecting them. The wall is very thin, and appears to be identified with the epitheca.

The endotheca is very abundant, thick, curved, and branching.

Height of various specimens 5 inches, $3\frac{8}{10}$ths inches, $2\frac{7}{10}$ths inches. Breadth of specimens 2 inches, $2\frac{8}{10}$ths inches, 2 inches.

Locality. Cherrington, Skipton-on-Stour.

In the Collections of the Geological Society, British Museum, Rev. P. B. Brodie, F.G.S., R. Tomes, Esq., &c.

This is the largest simple Coral of the British Fossil Coral-fauna, and is readily distinguished. Its variability of shape almost equals that of *Montlivaltia rugosa*, Wright.

There are some fragmentary Corals in the Marlstone, but their genera are doubtful; and the cast of a *Montlivaltia* was found by Mr. Charles Moore at Wells, but I cannot determine the species.

The Corals from the Middle Lias are—

1. *Lepidophyllia Hebridensis*, Duncan.
2. *Montlivaltia Victoriæ*, ,,

XXI. Total number of Species of Madreporaria which can be distinguished in the Lias of the British Islands.

In the zone of *Ammonites planorbis*	. . .	2[1]
,, ,, — *angulatus*	. . .	50
,, ,, — *Bucklandi*	. . .	7
,, ,, — *obtusus*	. . .	1[2]
,, ,, — *raricostatus*	. .	4
,, ,, — *Jamesoni*	. . .	1
,, ,, — *Henleyi*	. . .	1
		66
From the Upper Lias described by MM. Milne-Edwards and Jules Haime[3]	. . .	1
Total	. .	67

Lower Lias . . .	64
Middle Lias . .	2
Upper Lias . . .	1
Total . .	67

[1] See page 65.

Some are common to this and the next zone.

[3] 'Brit. Foss. Corals,' Pal. Soc.

XXII. Corals from the Zone of Ammonites planorbis.[1]

Division—Astræaceæ.

Genus—Isastræa.

1. Isastræa latimæandroidea, *Duncan*. Pl. XV, figs. 18, 19.

The corallum is massive, and has an angular and rather gibbous upper surface.

The corallites are long, and their united walls are thick.

The calices are very irregular in shape, and although some are small and polygonal, others are more like the serial calices of the genus *Latimæandra*. The calices are deep, and gemmation takes place quite on the margin.

The septa are numerous, very unequal, and there is a very small septum between the larger. The larger septa are very dentate, and the tooth near the axial space is very distinct, especially in the long calices. The larger septa are not very unequal, do not project much into the calice, and the axial space is left very free, but is closed by endotheca. The existence of the small rudimentary septa makes the septal number very irregular, and the long serial calices contain very variable numbers of septa.

The endotheca is strongly developed, is vesicular, and closes in the corallites.

Diameter of ordinary calices $\frac{2}{10}$ths inch to $\frac{3}{10}$ths inch.

Diameter of serial calices $\frac{2}{10}$ths inch. Length of serial calices $\frac{5}{10}$ths—$\frac{6}{10}$ths inch.

Locality. "No. 3" bed in the Street section.

In the Collection of Dr. Wright, F.G.S.

This is a most remarkable species, and the existence of serial calices with an abundant marginal gemmation is very suggestive. It renders the genus *Latimæandra* of rather doubtful value. The new species is readily distinguished by the calices and the dentate septa.

It is erroneously named *Isastræa Murchisoni* by some collectors.

The locality whence the specimen was derived is the same which yielded *Septastræa Haimei*, Wright, sp.

Genus—Thecosmilia.

Some small stunted Corals have been found in the "Guinea bed" at Binton, in Worcestershire. Only one specimen is fairly preserved, and its calice is so like that of *Thecosmilia Terquemi*, Duncan, from Brocastle, that it must be referred to that species.

[1] The specimens from the Zone of *Ammonites planorbis* were not forwarded for description until after the first part of this Monograph was finished.

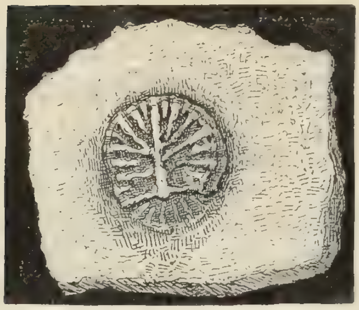


Fig. 1. *Thecosmilia Terquemi*, from the " Guinea Bed" at Binton.

The drawing of *Thecosmilia Terquemi* (Pl. III, fig. 11) greatly resembles the form from Binton, fig. 1, in the large septum which passes across the calice.

There are small Corals, probably *Thecosmiliæ*, in the " Guinea bed," at Wilmcote, but, as may be decided from the accompanying drawing, fig. 2, they are not determinable specifically.

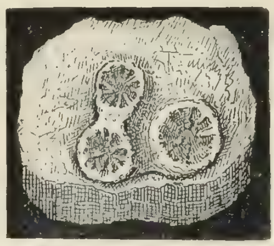


Fig. 2. *Thecosmiliæ*, from the " Guinea Bed " at Wilmcote.

XXIII. List of Corals from the Zone of Ammonites planorbis.

1. *Septastræa Haimei*, Wright, sp.
2. *Isastræa latimæandroidea*, Duncan.
3. *Thecosmilia Terquemi*, ,,

XXIV. Corals from the Zone of Avicula contorta and the White Lias.
(The Rhætic series, *Moore.*)

It has been noticed that but one fossil which could be referred to a Coral has been discovered in the Zone of *Avicula contorta* in England. The specimen is said to belong to the genus *Montlivaltia*, and to have a high septal number. The deposits containing

Avicula contorta in England, Wales, and Ireland, are not of that character in which Corals would be usually found; but the Azzarola beds of Lombardy are, as has been already noticed, highly coralliferous. The *Montlivaltia* from the British *Avicula contorta* series is, however, of some importance as a species, for it is the oldest Secondary form, there being no *Madreporaria* between it and the Carboniferous fauna except the few species of the Permian.

The White Lias, which was deposited under very different conditions to the *Avicula contorta* series, contains two genera of Corals, but the species are indeterminable, on account of the specimens being either in the form of casts or so altered by a destructive mineralization as only to present sections of their septa and part of the epithecal covering.

The White Lias of Watchet contains *Montlivaltiæ* and stunted conico-cylindrical *Thecosmiliæ*. A species of this last genus has its wall and epitheca very well shown (fig. 3).

Fig. 3. *Thecosmilia*, from the White Lias of Watchet.

No Thecosmilia from the White Lias can be determined to belong to the species *Michelini* or *Martini*, but there is a cast of a Coral in the White Lias of Sparkfield which has some resemblance to casts of *Thecosmilia Terquemi*, Duncan.

Fig. 4. Cast of a *Thecosmilia*, from the White Lias of Sparkfield.

Several specimens, probably, of *Montlivaltiæ*, from the White Lias of Warwickshire, are only distinguishable by the radiating septal laminæ (fig. 5).

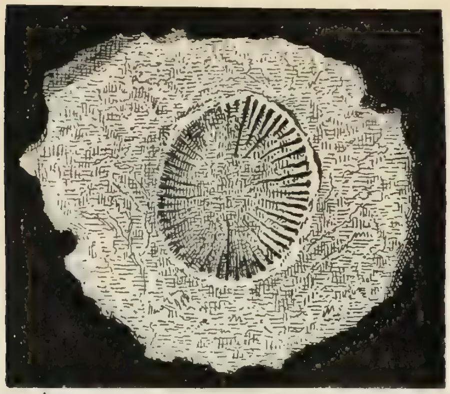


Fig. 5. *Montlivaltia,* from the White Lias of Warwickshire.

There is a great *Montlivaltia* in the Leamington beds, which is elliptical and very large at the calice. It is only found in the form of casts, one of which is here figured.

Fig. 6. Cast of a *Montlivaltia* from Leamington.

A cast of a multiseptate discoidal *Montlivaltia* is found at Punt Hill, Warwickshire, and I believe it to belong either to *Montlivaltia Haimei,* Chapuis et Dewalque, or to one of its varieties which have been noticed in the part No. 1 of this description of the Corals of the Lias. It is figured below.

Fig. 7. *Montlivaltia,* from Punt Hill, Warwickshire.

The great vertical range of this *Montlivaltia* has already been noticed. When the local nature of the White Lias is appreciated, and it is acknowledged as "a passage-bed" between the Zone of *Avicula contorta* and the beds containing *Ammonites planorbis,* the discovery of these Corals, which in the East of France and in Luxembourg are found in the *Ammonites planorbis* series, and in that of *Ammonites angulatus,* will not be exceptional.

XXV. APPENDIX.

Note on the Age of the Sutton Stone and Brocastle, &c., Deposits.

A long and very elaborate essay, by Mr. Charles Moore, F.G.S., has been read before the Geological Society, and published in the 'Quarterly Journal' of that society, with the title, "On Abnormal Conditions of Secondary Deposits when connected with the Somersetshire and South Wales Coal-Basin, and on the Age of the Sutton and Southerndown Series," which suggests that it is more or less controversial; but although this is the case, still it has great intrinsic merits.

Mr. Bristow, F.R.S., read a paper before the Geological Society, which appeared in its 'Quarterly Journal,' "On the Lower Lias or Lias-conglomerate of a part of Glamorganshire." Like Mr. Charles Moore's communication, it is very valuable, besides being controversial. Lately also Mr. R. Tate, F.G.S., in his essay "On the Fossiliferous Development of the Zone of *Ammonites angulatus*, Schlot., in Great Britain," has produced a palæontological criticism which refers in one part to the "abnormal deposits" and "the Lias-conglomerate."

Each of these essays refers to the characters and to the age of the Sutton Stone, whose Madreporaria have been described in this Part. Mr. Bristow considers the Southerndown series of Mr. Tawney[1] to be a portion of the Sutton Stone or "Lias-conglomerate," and asserts that Mr. Tawney has made a great error in his section of the sea face of the deposit by giving it too great an elevation. Mr. Bristow also considers the Sutton Stone to be Lower Lias, and that the usual *Gryphæa incurva* occurring in abundance renders his opinion incontrovertible. Mr. Moore, on the contrary, admits the correctness of Mr. Tawney's section, but considers that insufficient altitude has been given. He considers that, as *Ostrea Liassica* (*O. irregularis*) occurs high up in the series as a "zone," and as *Ammonites planorbis* is wanting, the Sutton Stone is in the "Ostrea division" of the *Ammonites planorbis* Zone. Mr. Moore places the Brocastle deposit in the Ostrea series. He insists upon the presence of *Gryphæa incurva* in the Sutton Stone and in the deposit at Brocastle "in abundance," and localizes the deposits in the Lower Lias.[2]

Mr. Tate proves what I had already demonstrated[3]—that Mr. Tawney placed the Sutton Stone too low down in the geological scale; and, after a survey of the beds above the White Lias in Ireland and England, he considers that the *Ammonites planorbis* Zone is

[1] Tawney, 'Quart. Jour. Geol. Soc.,' vol. xxii, p. 91.

[2] A palæontological combination of the forms of the lower part of the Zone of *Ammonites planorbis* with *Gryphæa incurva* would indeed be incredible.

[3] P. Martin Duncan, 'Quart. Jour. Geol. Soc.,' Feb., 1867; and in the 1st No. of this Part.

so mixed up with that of the *Ammonites angulatus* that it had better disappear from British geology.

Mr. Tate, however, supports indirectly the geological position I have given, from the study of the Madreporaria, to the Sutton Stone and Brocastle deposits.

I agree with Mr. Bristow, or rather he agrees with me, as I was first in the field, that the Sutton Stone is what is usually called Lower Lias;[1] but I dispute the possibility of associating the Sutton Stone, Brocastle, and other equivalent deposits, including, of course, the Coral-bed of Cowbridge, with the strata composing the *Ammonites Bucklandi* Zone in the same division of a great formation.

The word "Infra-Lias," which refers to the deposits below the *Ammonites Bucklandi* series, does not assume separation from the Lias, and, although Low, Lower, and Lowest will apply to some places, it would rather confuse a geological series.

To combine in one division of the Lias, under the term Lower, such zones as those of *Ammonites raricostatus* and *Ammonites planorbis* is to associate widely different faunæ. There are many species which have a great range in this division of the Lias, but there is a clear palæontological distinction to be drawn in the British Isles, in France, Luxembourg, and in Germany, between the faunæ of the Zone of *Ammonites Bucklandi* and of those below.

Ostrea irregularis (*O. Liassica*) is a shell so widely distributed, and has so great a vertical range, that it is of no value in fixing a geological horizon. It must be considered in relaton to the fauna associated with it; and the forms found in the Sutton Stone in company with this variable Oyster are not those which elsewhere characterise the Ostrea beds of the *A. planorbis* Zone.

I have examined the *Gryphææ*, and do not consider them typical *incurvæ*. The characters of the Molluscan and Madreporarian fauna which I have already pointed out, and the affinities and grouping of the species, induce me to retain my opinion that the Sutton Stone, the Brocastle, Ewenny, and Cowbridge deposits are on one geological horizon, and still to assert that they are the equivalents of the French and Luxembourgian Zones of *Ammonites angulatus.*

The deposits have a different Coral-fauna to the corresponding beds in the east of England, where simple *Montlivaltiæ* indicate different external conditions, but not a difference in time.

Corals from the Upper Lias.

MM. Milne-Edwards and Jules Haime described *Thecocyathus Moorei*, Ed. and H., from the Upper Lias of Ilminster. Mr. Charles Moore has sent me specimens from Lansdown, near Bath. The same excellent collector has a fossil, probably a Sponge, with

[1] Sir Henry de la Beche was the first to pronounce the Sutton Stone to belong to the Lower Lias.

markings upon it like those of a cast of the calice of a Coral; it is from Ilminster. *Trochocyathus primus*, Ed. and H., is too doubtful a species to be admitted into the Liassic Coral-fauna at present.

I have to acknowledge with many thanks the great assistance I have received in completing this Monograph of the Corals of the Lias from Mr. H. Woodward, of the British Museum, Mr. R. Etheridge, of the School of Mines, and Mr. R. Tomes, besides those gentlemen whose collections have been placed at my service. (See Preface to Part IV, No. 1.)

ERRATUM.

In the Preface to Part IV, No. 1, "*Trochocyathus Moorei*, Ed. and H.," should be "*Thecocyathus Moorei*, Ed. and H."

INDEX OF THE SPECIES, ETC.

DESCRIBED AND NOTICED IN

Part IV, No. 1 and No. 2,

CORALS FROM THE LIAS.

	PAGES
Astrocœnia costata . .	21, 50.
,, dendroidea . .	22, 50.
,, favoidea . .	21, 50.
,, gibbosa . .	18, 48, 50.
,, insignis . .	19, 50.
,, minuta . .	22, 50.
,, parasitica . .	20, 50.
,, pedunculata .	20, 50.
,, plana . .	19, 50.
,, reptans . .	20, 50.
,, Sinemuriensis .	22, 33, 34, 49, 50.
,, superba . .	21, 50.
Astrocœniæ, notes on the .	26.
,, scheme of the .	23.
Cyathocœnia costata . .	29, 50.
,, dendroidea .	27, 50.
,, globosa . .	55, 62.
,, incrustans .	28, 50.
Elysastræa Fischeri . .	29, 50.
,, Moorei . .	30, 50.
Isastræa Condeana . .	49, 51.
,, endothecata . .	53, 55, 62.
,, globosa . .	31, 48, 51.
,, insignis . .	54, 55, 62.
,, latimæandroidea .	65, 66.
,, Murchisoni . .	41, 47, 51.
,, Sinemuriensis . .	30, 33, 34, 51.
,, Stricklandi . .	54, 55, 62.
,, Tomesii . .	46, 51.

	PAGES
Latimæandra denticulata .	32, 43, 50.
Lepidophyllia, genus of . .	41, 53.
,, Hebridensis .	62, 64.
,, Stricklandi .	53, 55, 62.
Montlivaltia brevis . .	10, 49.
,, dentata . .	48, 49.
,, denticulata .	48, 49.
,, discoidea . .	48, 50.
,, Gastaldi . .	48.
,, Guettardi . .	48, 50, 51, 55, 61.
,, Haimei . .	35, 40, 48, 49.
,, Hibernica . .	39, 40, 49.
,, Martini . .	48, 49.
,, mucronata . .	59, 61.
,, Murchisoniæ .	8, 49.
,, nummiformis .	60, 61.
,, papillata . .	36, 38, 40, 49.
,, parasitica . .	9, 49.
,, patula . .	56, 61.
,, pedunculata .	10, 49.
,, polymorpha .	8, 33, 48, 49.
,, radiata . .	61, 62.
,, Rhodana . .	48, 49.
,, rugosa . .	57, 58, 61.
,, Ruperti . .	46, 49.
,, simplex . .	9, 49.
,, Sinemuriensis .	48, 49.
,, Walliæ . .	7, 49.
,, Victoriæ . .	63, 64.
Oppelismilia gemmans . .	39, 40, 41, 49.

	PAGES
Rhabdophyllia De-Filippi	48.
,, Langobardica	47, 48.
,, Menighini	48.
,, recondita	17, 42, 50.
,, Sellæ	48.
Septastræa Eveshami	52, 55, 62.
,, excavata	32, 33, 49, 50.
,, Fromenteli	37, 40, 48, 50.
,, Haimei	5, 6, 66.
Stylastræa Martini	49, 50.
,, Sinemuriensis	49, 50.
Stylina Savii	48.
Thamnastræa Batarræ	48.
,, Escheri	48.
,, Meriani	48.
,, rectilamellosa	48.

	PAGES
Thecocyathus Moorei	i, 71.
,, rugosus	57, 58, 61.
Thecosmilia affinis	16, 42, 50.
,, Brodiei	13, 42, 50.
,, coronata	48, 50.
,, dentata	16, 42, 50.
,, irregularis	15, 42, 50.
,, Martini	14, 33, 45, 48, 50, 51.
,, Michelini	14, 33, 45, 48, 50, 51.
,, mirabilis	12, 42, 50.
,, plana	17, 42, 50.
,, rugosa	13, 50.
,, serialis	12, 42, 50.
,, Suttonensis	11, 42, 50.
,, Terquemi	16, 42, 50, 65, 66.
Trochocyathus primus	71.

PLATE XII.

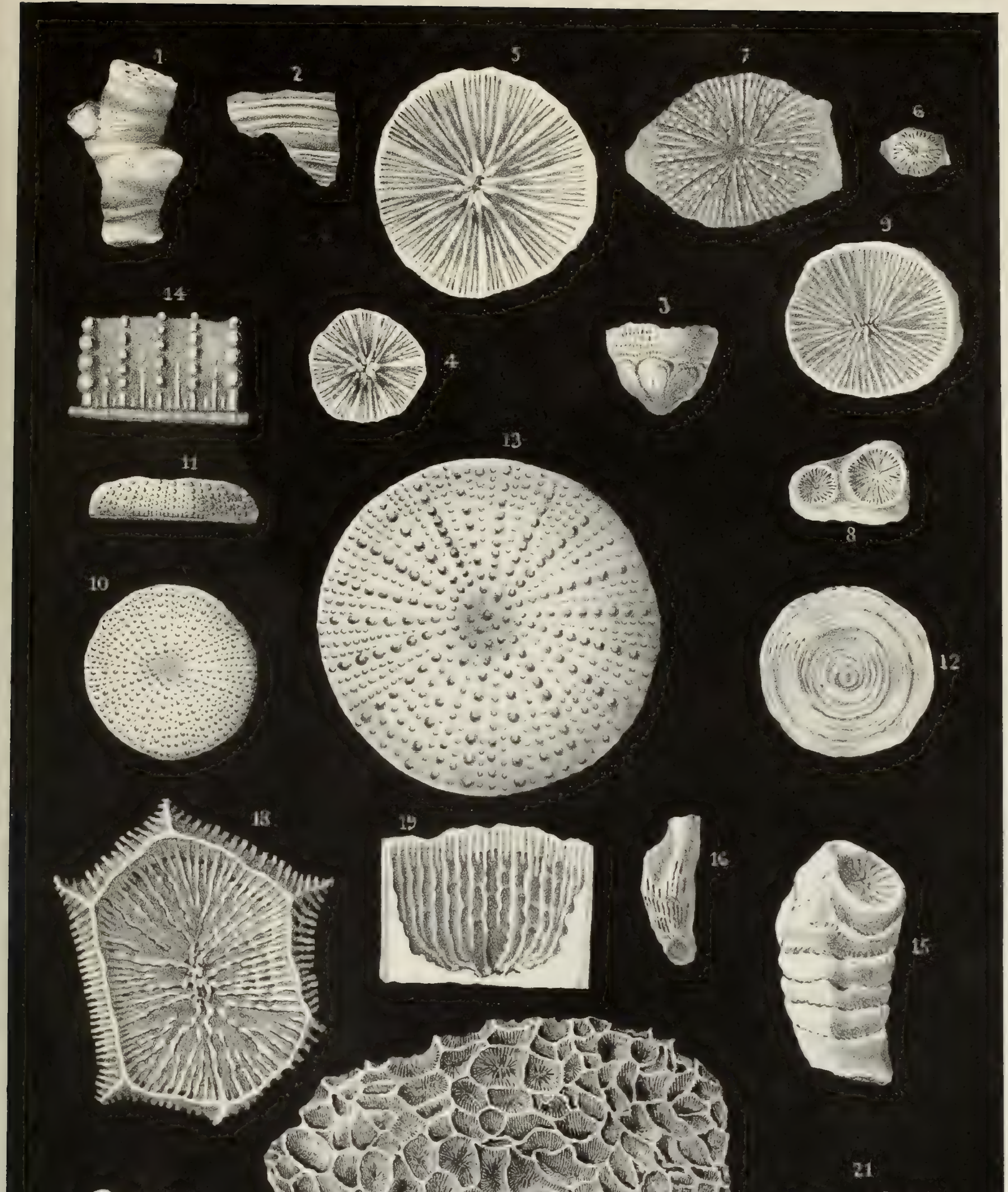
CORALS FROM THE LOWER LIAS.

FIG.

1. *Thecosmilia Martini*, E. de Fromentel. (P. 45.)
2. Part of its epitheca magnified.
3. *Montlivaltia Ruperti*, Duncan. (P. 46.)
4. Its calice.
5. The calice, magnified.
6. A young specimen of *Montlivaltia Guettardi*, Blainville. (P. 51.)
7. The calice, magnified.

10. }
11. } A full-grown specimen. (P. 51.)
12. }

13. Its calice, magnified.
14. The septa, magnified.
8. The calicular surface of a young *Thecosmilia Martini*.
9. The same, magnified.
15. *Lepidophyllia Stricklandi*, Duncan. (P. 53.)
16. A cast of *Thecosmilia Michelini*, Terquem. (P. 51.)
17. Part of the corallum of *Isastræa endothecata*, Duncan. (P. 53.)
18. A regular calice, magnified.
19. A side view of a magnified calice, showing the endotheca in the calice.
20. Oblique view of some calices, magnified.
21. Endothecal dissepiments connecting the septa, magnified.



M & N Hanhart imp

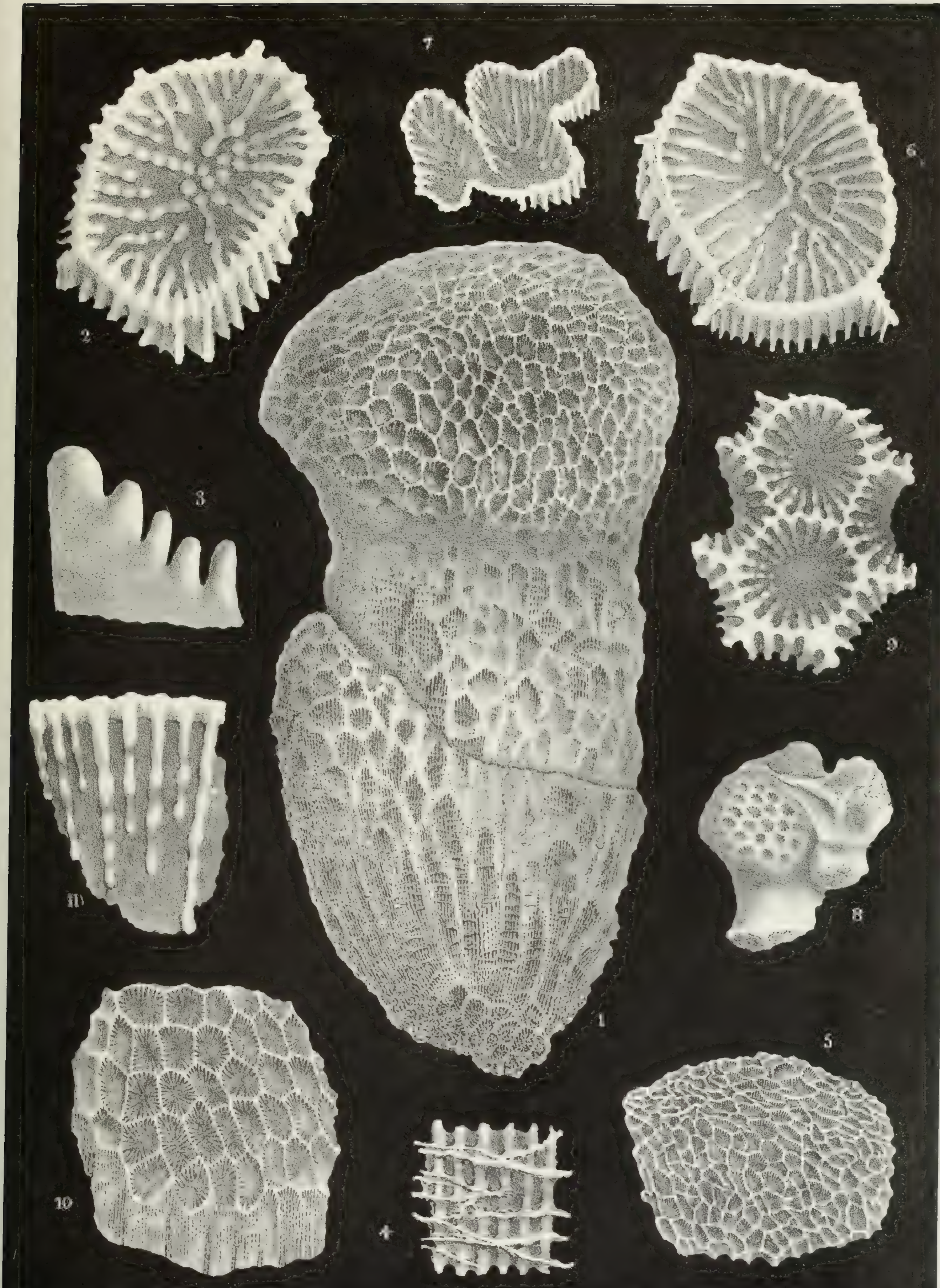
LIASSIC CORALS

PLATE XIII.

CORALS FROM THE LOWER LIAS.

Fig.

1. The corallum of *Isastræa Stricklandi,* Duncan. (P. 54.)
2. A calice, magnified.
3. The dentations of a septum, magnified.
4. The strong dissepimental endotheca, magnified.
5. Part of the corallum of *Septastræa Eveshami,* Duncan. (P. 52.)
6. A calice, magnified.
7. An irregular and contorted calice, magnified.
8. The corallum of *Cyathocœnia globosa,* Duncan. (P. 55.)
9. Calices of *Cyathocœnia globosa,* magnified.
10. Part of the corallum of *Isastræa insignis,* Duncan. (P. 54.)
11. A system of four cycles of septa, magnified.



De Wilde lith

M & N Hanhart imp

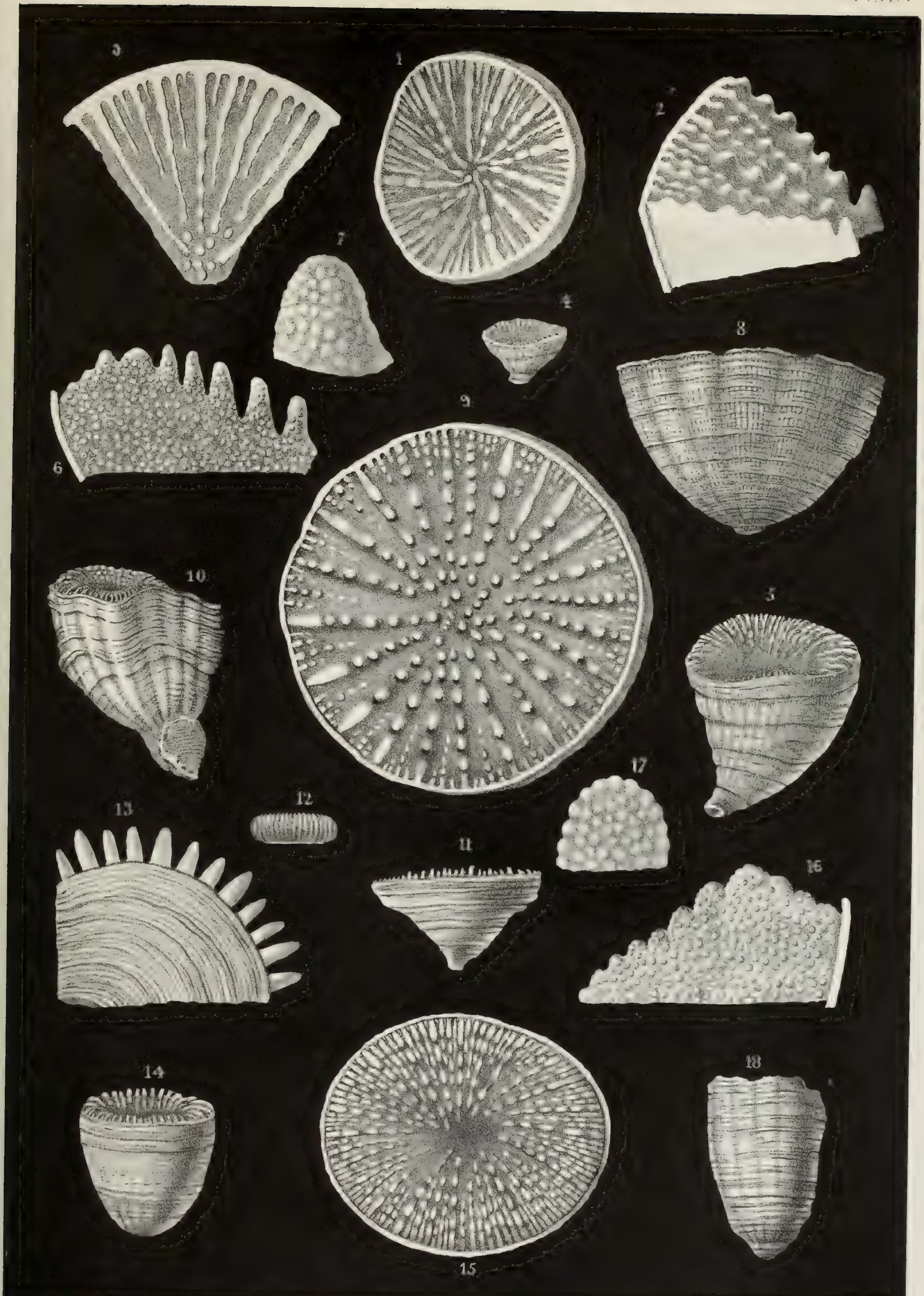
LIASSIC CORALS.

PLATE XIV.

CORALS FROM THE LOWER LIAS.

FIG.

1. A calice of *Montlivaltia rugosa*, Wright, magnified. (Pp. 58.)
2. An oblique view of some dentate septa of the same species, magnified.
3. A portion of a worn calice, magnified, showing the irregular septal arrangement of some specimens of this species.
4. A young specimen of *Montlivaltia mucronata*, Duncan. (Pp. 59.)
5. A variety of *Montlivaltia mucronata.*
6. One of its septa, magnified, showing the mucronate processes and the granular ornamentation.
7. One of the processes, magnified.
8. A side view of the corallum of a full-grown individual, rather enlarged.
9. A calice of a full-grown *Montlivaltia mucronata*, magnified. (Pp. 59.)
10. A deformed specimen of a variety of *Montlivaltia mucronata.*
11. A conical variety of *Montlivaltia mucronata.*
14. A variety of *Montlivaltia mucronata*, with a deeper calice than the type.
15. The calice, magnified.
16. One of its septa, magnified.
17. A process, magnified.
18. A variety of *Montlivaltia mucronata.*
12. The corallum of *Montlivaltia nummiformis*, Duncan. (P. 60.)
13. The basal epitheca and projecting septa, magnified.



De Wilde lith. M & N Hanhart imp.

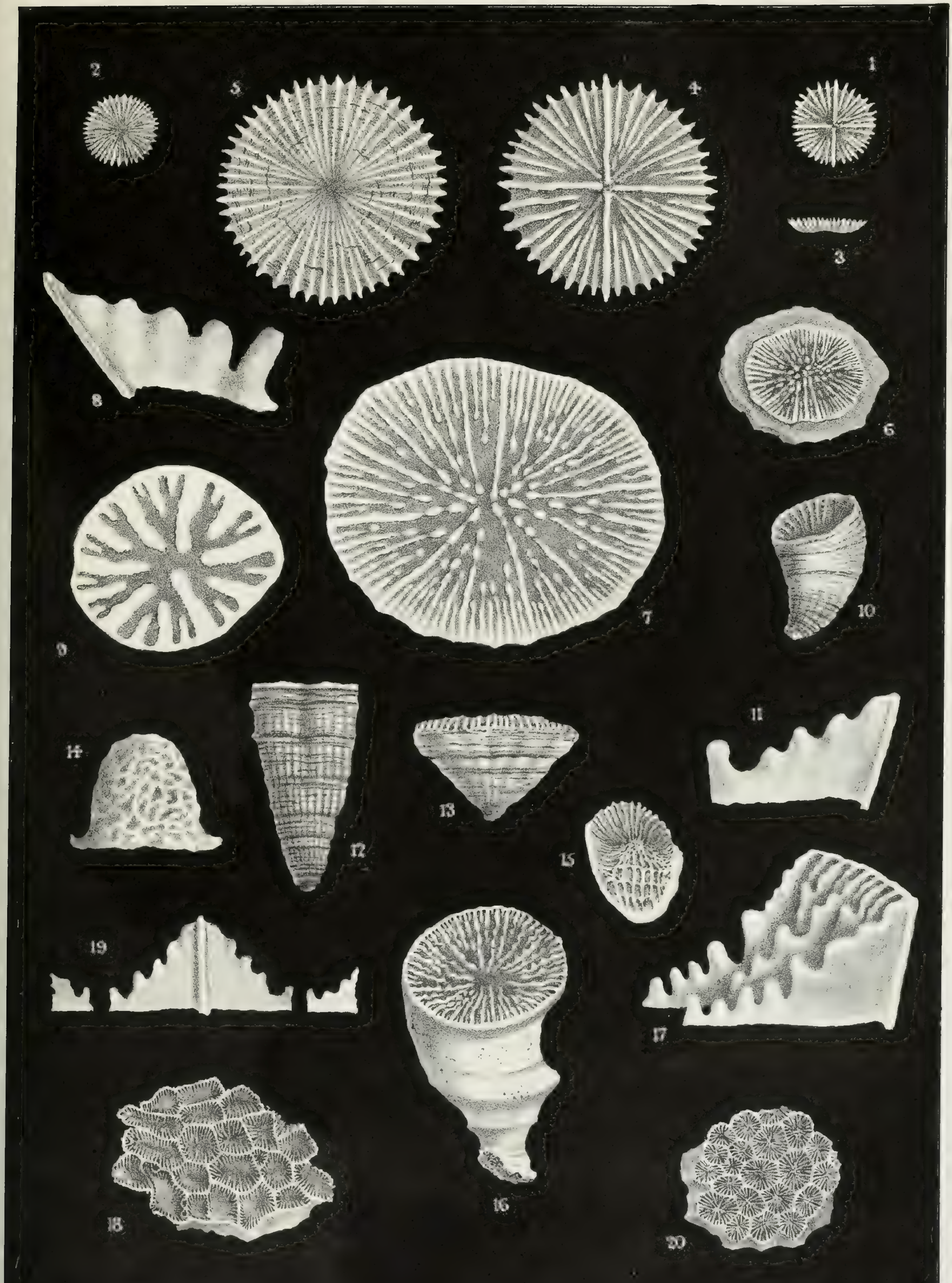
LIASSIC CORALS

PLATE XV.

CORALS FROM THE LOWER LIAS.

Fig.

1. The upper calicular surface of *Montlivaltia radiata*, Duncan. (P. 61.)
2. The under surface.
3. A side view of the corallum, showing the central depression of the base.
4. The calice, magnified, showing the quaternary arrangement of the septa.
5. The base, magnified, showing the pellucid epitheca and the costæ.
6. The corallum of *Montlivaltia patula*, Duncan. (P. 56).
7. The calice, magnified.
8. Part of the wall and one of the septa, magnified, showing the direction of the teeth.
9. A very young *Montlivaltia*, of an unknown species. The calice magnified (P. 52.)
10. A cornute variety of *Montlivaltia mucronata*, Duncan. (P. 60.)
11. One of its septa, magnified.
12. A portion of the external surface of the type of *Montlivaltia mucronata*, Duncan, showing the dichotomous longitudinal bundles of costæ, magnified.
13. A conical variety of *Montlivaltia mucronata*, Duncan.
15. A section, magnified, of *Montlivaltia Ruperti*, Duncan.
16. A large and unusual shape of *Montlivaltia rugosa*, Wright.
17. A side view of its dentate septa.
14. A dentate process, magnified, showing the ornamentation.
18. The corallum of *Isastræa latimæandroidea*, Duncan. (P. 65.)
19. Its septa, magnified.
20. The corallum of *Isastræa Tomesii*, Duncan. (P. 46.)



De Wilde lith.

M & N Hanhart imp.

LIASSIC CORALS.

PLATE XVI.

CORALS FROM THE LOWER AND MIDDLE LIAS.

FIG.

1. *Lepidophyllia Hebridensis*, Duncan. Natural size. (P. 62.)
2. Calices, magnified, showing calicular gemmation.
3. Side view of corallites, showing the epitheca.
4. Septa, magnified.

5., 6., 7., 9. Common forms of *Montlivaltia rugosa*, Wright, sp. (P. 58.) / *Thecocyathus rugosus*, Wright, MS.

10., 11., 12., 13., 14. Unusual and young forms of the same species.

8. Septal ends (external) and intermediate endotheca (magnified).

15. A section magnified, showing the strong and arched endotheca between the septa.

De Wilde lith

M & N Hanhart imp

LIASSIC CORALS

PLATE XVII.

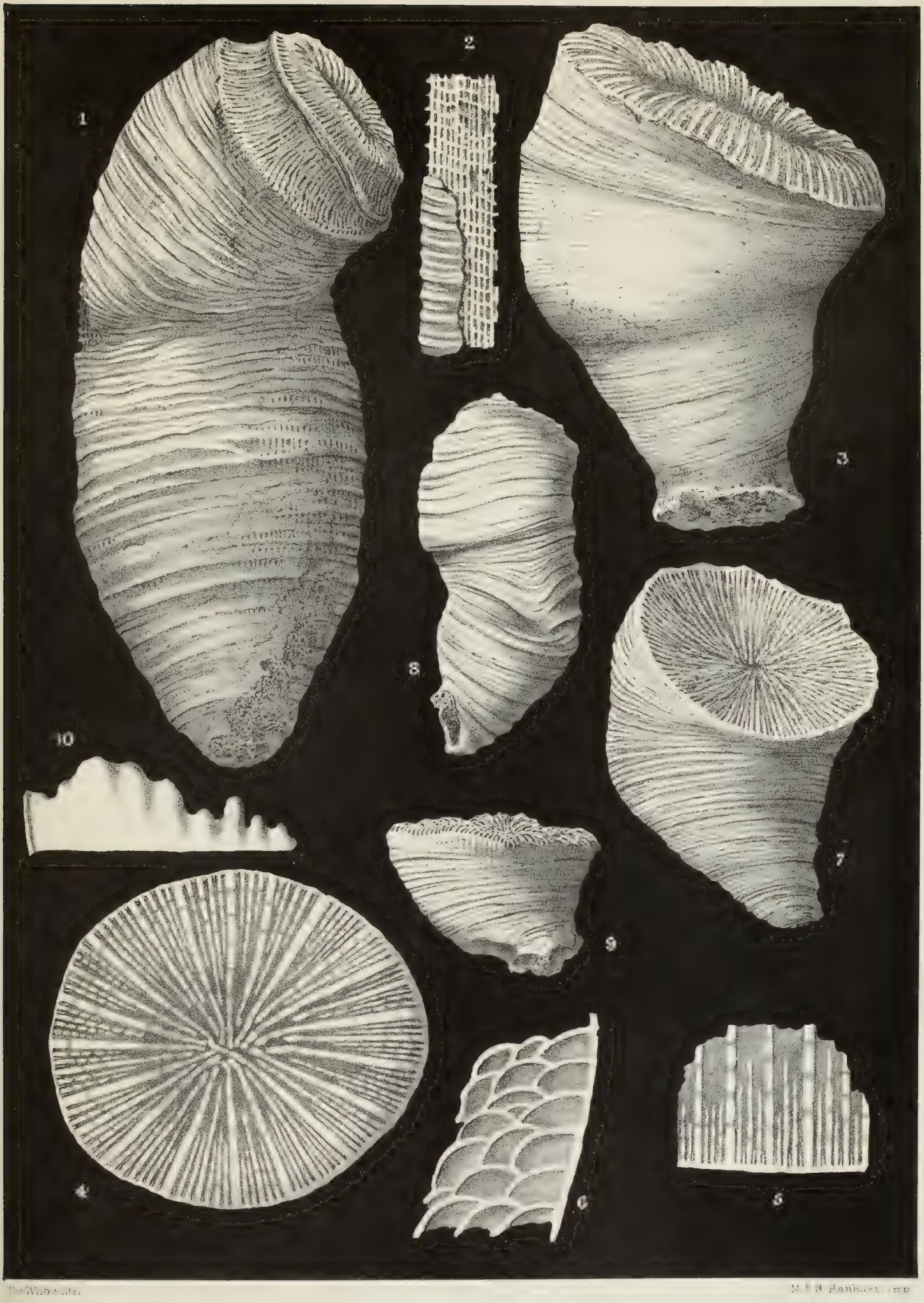
CORALS FROM THE MIDDLE LIAS.

FIG.

1. *Montlivaltia Victoriæ,* Duncan. Nat. size. A corallum, with a constriction near the calice. (P. 63.)
2. A magnified view of some septal (external) ends, with endotheca, simulating costæ and exotheca. The epitheca is shown covering these structures.
3. A specimen with a large calice.
4. A calice slightly magnified. The rudimentary septa are shown as faint white lines close to the thin margin.
5. Diagram of the septa.
6. Slightly magnified view of the thin epithecal wall and the curved endotheca.

7. }
8. } Different forms of the species.
9. }

10. A septum, magnified.



M & N Hanhart imp.

CORALS

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1867.

LONDON:

MDCCCLXVIII.

A MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

THOMAS WRIGHT, M.D., F.R.S. EDIN., F.G.S.,

CORRESPONDING MEMBER OF THE ROYAL SOCIETY OF SCIENCES OF LIÈGE, THE SOCIETY OF NATURAL SCIENCES OF NEUFCHATEL, AND SENIOR SURGEON TO THE CHELTENHAM HOSPITAL.

VOLUME FIRST.

PART SECOND.

ON THE CIDARIDÆ AND DIADEMADÆ.

PAGES 65—112; PLATES IX, X, XII—XXI, XXI A, XXI B.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1868.

PRINTED BY J. E. ADLARD, BARTHOLOMEW CLOSE, E.C.

Description.—This beautiful *Cidaris*, formerly identified by Professor E. Forbes as a variety of *C. sceptrifera*, and afterwards catalogued by him as a distinct species, under the name *C. sulcata*, had been previously considered by the Abbé Sorignet, from its spines alone, as a new form, and described in 1850 as *C. hirudo* in his work on the 'Oursins fossiles du département de l'Eure,' and this name has the priority.

The test of the fine specimen belonging to Henry Willett, Esq., F.G.S., and fully illustrated in Pl. IX., fig. 1 *a, b, c*, attains a moderate size, is inflated at the equator, and equally flattened at the poles. The ambulacral areas are narrow, sinuous, and band-like, forming prominent, well-marked segments in the test, filled with small, close-set, regularly arranged rows of granules; there are six rows at the equator, four rows in the upper and lower thirds, and two rows only near the discal and oral apertures. The most prominent granules are in the external rows; they are slightly mammillated and extend throughout the entire area. Pl. IX, fig. 2 *b*, is an equatorial inter-ambulacral plate, with the ambulacral area attached, magnified three diameters. In the second row the granules are nearly as large, and extend through eight tenths of the area; the third rows extend through the height of two large plates; the granules are set very closely together, and regularly arranged in transverse rows. The poriferous zones are narrow, depressed and flexuous, fig. 2 *b*; the pores are small and round, and the septum supports a small round granule; the entire series of septal granules forms a moniliform line between the pores, which gives an apparent lateral extension to the width of the area; and opposite one of the large plates there are twenty-three pairs of pores.

The inter-ambulacral areas are wide, the plates composing them being deep and broad, five or six in each column; the areolas are circular and moderately depressed; they are closely approximated on the under side, wider apart at the equator, and still further apart above.

Pl. IX, figs. 1 and 2, Pl. X, figs. 1, 2, 3, show the character of the areolæ; the margin is slightly elevated (Pl. IX, fig. 2 *b*) and encircled by a row of larger mammillated granules; the uppermost plate in each alternate column has a rudimentary wart-like tubercle without areola (Pl. IX, fig. 1 *a, b*); and in the other column the tubercle is small, but complete, and surrounded by a narrow shallow areola (fig. 1 *a, b*); the base has a smooth flat summit, with only rare indications of crenulations; those in fig. 2 *b*, are strongly drawn: the tubercle is large and perforated. The miliary zone is wide, depressed along the middle of the area, and along the transverse lines of the sutures: the granulations on the surface of the plates are large in size and uniform in arrangement thereon.

The apical disc (Pl. IX, fig. 2 *a*) is large, and composed of five ovarial and five ocular plates; the rhomboidal ovarials are widely perforated, and the cordate oculars have small marginal orbits in the disc (fig. 2 *c*); the aperture is pentagonal, and there are indications of the outer series of small anal plates.

The mouth-opening (Pl. IX, fig. 3, and Pl. X, figs. 1 *a*, and 3 *b*) is small, and the peristome slightly pentagonal; in Pl. IX, fig. 3, there is a rudiment of a jaw and tooth.

The spines exhibit a considerable variation of form; in some they are elongated and cylindrical, as in Pl. IX, fig. 1 *b;* or elongated and subfusiform, as in fig. 5, and Pl. X, fig. 1 *b,* and figs. 5, 6. In all the stem is slightly enlarged in the middle, and tapers towards the upper third. The surface in some specimens is sculptured with fine longitudinal lines, as in Pl. IX, fig. 1, and Pl. X, figs. 1, 4, 6; or has granulated ridges with intervening valleys, as in Pl. IX, fig. 5, and Pl. X, fig. 5. The summit is truncated more or less in all the specimens, and exhibits a stellate figure with several central convexities as in Pl. IX, figs. 4 *a,* and 4 *c,* 5, the radii being formed by the development of the longitudinal ridges.

In the more finely sculptured spines the longitudinal lines on the stem have a granuliform structure; the intervening valleys are finely shagreened throughout, and provided with delicate subgranular striæ. The neck is short, distinctly defined, with a finely sculptured line above the ring (Pl. IX, figs. 4, 5, Pl. X, figs. 1, 4, 6).

The milled ring is moderately prominent, with coarser lines than those on the neck; the articular cavity is smooth, or has some feeble crenulations on its margin (Pl. IX, figs. 4, 5, Pl. X, figs. 1, 4, 6).

Affinities and Differences.—This form has long been considered to be a mere variety of *C. sceptrifera;* the proximal discal plate, however, has generally a rudimentary tubercle of larger size and rounder shape than that found on *C. sceptrifera.* The second discal plate (counting downwards) has the upper three quarters of the boss much more strongly crenulated than in the other species (at p. 64 the upper bosses of *C. hirudo* were accidentally stated to be not crenulated). The large size of the areolas, their comparative continuity, the prominent mammillated granules upon their circumference, and the circumstance of the highest areola bearing a perfect tubercle being distant from the anal margin by not more than half its diameter, easily separate this species from *C. sceptrifera,* in which the areolas have more sloping borders, smaller and more numerous mammillated granules, and in which the highest areola bearing a perfect tubercle is generally distant from the anal margin by the length of its diameter. The spines are much shorter and more uniform in diameter than in *C. sceptrifera,* having their greatest swelling midway between the acetabulum and summit, instead of towards the former; their extremities are more truncated, often becoming stellate, as on Plate IX. fig. 4 *c;* their surface is covered with longitudinal ridges, armed with very much shorter spiny projections, often almost obliterated; the collar is shorter, and the acetabulum is marked with stronger crenulations. *C. hirudo* is a rather small species, less than *C. sceptrifera,* and not so common. An average size will be about one inch and one tenth in transverse diameter, height six tenths, length of spine one inch, greatest diameter of spine three twentieths.

Locality and Stratigraphical Position.—The specimens I have examined have been collected from the White Chalk of Sussex and Gravesend. In France M. Cotteau gives the following localities where this Urchin is common—the Étage Cénomanien, de Havre

(Seine-Inférieure), Fourneaux la Madeleine (Eure), Saint-Parres près Troyes (Aube), Étage Sénonien Inférieure, Etretat (Seine Inférieure), Tartigny (Oise), Châlons-sur-Marne (Marne).

History.—The Abbé Sorignet in 1850 described a spine of this species under the name *C. hirudo.* The same year the test was well figured with its spines attached by the late Mr. F. Dixon, and described by the late Professor Forbes as *C. sceptrifera* var. *spinis truncatis;* subsequently it was found that Mr. Dixon had given it the MS. name *C. sulcata,* under which name it appeared in the second edition of the 'Catalogue of British Fossils,' and in Dr. Woodward's notes on Cidaris in the Fifth Decade of the 'Memoirs of the Geological Survey.' The Abbé Sorignet's name has been properly retained by M. Cotteau in his continuation of D'Orbigny's Paléontologie Française.

Cidaris Dixoni, *Cotteau.* Pl. XI, fig. 4; Pl. XII, fig. 6.

Cidaris. *Dixon,* Geol. of Sussex, p. 339, pl. xxiv, fig. 25, 1850.
Cidaris Dixoni, *Cotteau.* Paléontologie Française, tom. vii, p. 238, pl. 1051, fig. 78, 1862.

The test of this fine Urchin is unknown.

Description.—Spine very large; stem thick, oblong, glandiform, much enlarged in the middle, and tapering towards the neck and apex; the lower part is covered with convex, scale-like plates, arranged without much regularity; in the middle part they are larger, and have much the same character; at the upper third they are less closely set together, become ridged, and form granulated lines, which pass towards the summit; the intervening valleys are covered with fine longitudinal lines.

The neck is short and smooth, although there are traces of longitudinal lines; the milled ring is not prominent, and the articular cavity indicates a small tubercle; the rim of the acetabulum is smooth.

Dimensions.—Length of the entire spine, from acetabulum to apex, $1\frac{7}{10}$ths of an inch; length of neck and head $\frac{3}{10}$ths of an inch; length of stem $1\frac{4}{10}$ths of an inch; thickness of stem, at widest part, $\frac{8}{10}$ths of an inch.

Locality and Stratigraphical Position.—Found in the Grey Chalk near Folkestone by the Rev. T. Wiltshire, F.G.S., whose cabinet contains a very fine specimen. Mr. Dixon's type, which formed the subject of fig. 4, Pl. XI, is in the collection of Henry Willett, Esq., F.G.S. M. Cotteau records two specimens from the Étage Cénomanien, at Havre (Seine Inférieure), where it is very rare.

Cidaris pleracantha, *Agassiz.* Pl. XI, fig. 5; Pl. XII, fig. 5.

Cidaris pleracantha, *Agassiz.* Catal. Syst. Ectyp. Foss., p. 10, 1840.
— — *Sorignet.* Oursins foss. de l'Eure, p. 4, 1850.

Cidaris pleracantha, *D'Orbigny*. Prodrome de Pal. Strat., t. ii, p. 274, Ét. 22, 1850.
— — *Dixon*. Geology of Sussex, tab. xxiv, fig. 23, 1850.
— — *Desor*. Synopsis des Échinides foss., t. vi, fig. 7—10, p. 14, 1855.
— — *Woodward*. Mem. Geol. Surv. Decade V, Expl., pl. v, p. 3, 1856.
— — *Cotteau*. Paléontologie Franç., Ter. Crét., tom. vii, tab. 1075, fig. 1—13, p. 310, 1865.

Test unknown.

Description.—Spine very large, inflated, pyriform, with an obtuse and unequally rounded summit; stem ornamented with longitudinal striæ, very fine or subgranular, and visible near the lower part, the upper part is smooth; the stem suddenly contracts to form a very short neck and a small head; milled ring a little elevated and marked by fine lines; acetabulum small with a smooth ring.

Spines of this species are very rare indeed in the English Cretaceous rocks. The specimens collected at Meudon, near Paris, and at Civières (Eure), vary much in form and dimensions; some are short, thick, or pyriform, and have the stem round or depressed at the summit, or inflated, subcylindrical, accuminated, or truncated; and in a large specimen before me from France the stem is bifurcated.

Locality and Stratigraphical Position.—Mr. Dixon's specimens were said to have been found in the Grey Chalk of Sussex. It occurs also in the Lower Chalk of Dorking. The specimen figured, Plate XII, fig. 5, in the Cabinet of J. R. Capron, Esq., F.G.S., came from that locality.

Cidaris Farringdonensis, *Wright*. Pl. II, figs. 6, 7, and 8 *a*, *b*, *c*.

Test known only by isolated plates.

Description.—Spines long, slender; lower portion of the stem smooth, upper portion ornamented with longitudinal rows of granules forming tuberculated lines or ridges in different spines, and terminating in a star-shaped summit at the apex. The proportional length of the smooth to the granulated ornamentation of the stem varies in different spines —in some with a long smooth portion the line of separation is defined by an annular elevation, in others with a shorter smooth portion the granulations arise without any such ridge. The valleys between the longitudinal ridges have a finely shagreened surface; the head is moderate in size, the milled ring prominent, and the small acetabulum has a well-defined marginal rim.

The isolated plates of the test are much worn by friction; the primary tubercle is small, the areola wide and smooth, and the margin surrounded by a circle of large well-defined granules, resembling the plates of *Cidaris vesiculosa*.

Affinities and Differences.—The spines of *Cidaris Farringdonensis* differ so much from

all other forms at present known that they cannot be mistaken for any other species, the long smooth lower portion of the stem forming such a conspicuous specific character of this spine.

Stratigraphical Position.—The specimens I have figured were collected from the Sponge-gravel near Farringdon, in Berkshire, associated with *Pseudodiadema rotulare*, Ag., *Hyposalenia Wrightii*, Desor, *Hyposalenia Lardyi*, Desor, *Salenia areolata*, Wahlb., and two new species of *Echinobrissus*, together with the Amorphozoa and Mollusca that characterise this remarkable formation.

My kind friend the Rev. T. Wiltshire, F.G.S., at my request, has contributed the following additional notes on some rare tests and spines of *Cidares* in his collection. These are figured in Pls. XII and XIII.

"In the course of last year you expressed the desire that I should send you some notes in reference to the fossils figured in Plates XII and XIII of your Monograph on the Cretaceous Echinodermata. In compliance, therefore, with your wish, the following remarks are forwarded, to be used or rejected as may seem most fitting.

"The Urchin drawn in figure 1, Plate XII, is probably a new species intermediate between *Cidaris sceptrifera* and *C. subvesiculosa.* I would suggest it should be named *C. intermedia;* it may be thus defined:—

Cidaris intermedia, *Wiltshire.* Pl. XII, figs. 1 *a*, 1 *b*.

"Test moderately large, inflated; ambulacral areas narrow, depressed, flexuous, with six rows of granules in the middle, the outer two the largest, diminishing to four rows above and below; poriferous zones winding, narrow, depressed, at the ambitus about the same width as the semi-ambulacral areas, narrower above, wider below; interambulacral areas wide, plates large, five in a column; areolas proximate, deep, suboval, with an elevated slightly overhanging scrobicular margin, encircled by a series of small granules, equal in dimensions to those of the outer row of the ambulacral areas, bosses not prominent, summit smooth, tubercle moderate in size, perforated; proximal discal plate in each column with a rudimentary tubercle, in a circular area; miliary zone narrow, filled with small equal-sized granules depressed along the line of sutures; apical disc wide, of the same diameter as the peristome; ovarial plates thick; jaws stout, triangular; spines long, slender, cylindrical, slightly tapering, surface marked by regular longitudinal rows of spiny projecting granules, the intervening space finely shagreened.

"*Dimensions.*—Height $\frac{7}{10}$ths of an inch (the specimen being very slightly crushed); transverse diameter 1 inch and $\frac{6}{10}$ths.

"*Description.*—The test of this Urchin is circular, and is equally depressed at both

poles; the ambulacral areas are narrow and flexuous, rather more so than in *C. sceptrifera*, rather less so than in *C. subvesiculosa;* granules six in number at the ambitus, diminishing to four at the poles; the central rows at the upper and under surfaces minute and irregular; the four central rows at the ambitus composed of granules of less size than those of the exterior rows, consisting of greater numbers, and somewhat irregularly arranged; the poriferous zones are narrow and depressed, and follow the flexures of the areas; the pores are round, closely situated, and disposed obliquely; there are eighteen pores (thirty-six in all) opposite one of the largest plates; the interambulacral areas are very wide, five to six plates in a column; the areolas are wide, slightly oval (the minor axes being towards the poles) at the ambitus, circular at the peristome and anal margins, and are surrounded by an undercut overhanging border, encircled by a series of about twenty granules, each raised on a distinct shield-like mammillated plate; the areolas at the equator have their borders separated from the upper and under plates by a small interval occupied by about five sets of granules; at the under surface these granules are absent, and the scrobicular margins are in contact; at the upper surface the granules increase in number; the penultimate plate of the anal surface has an areola rather larger than that below; the final plate has a rudimentary tubercle in a small circular areola, this last plate is covered with granules; the boss is not prominent, its summit is smooth and without crenulation, the tubercle is moderately large and perforated; the miliary zone is narrow, and the granules are so arranged as to present the appearance of radiating from the scrobicular margin towards the sutures; they are much smaller than those surrounding the areolas; the surface on which they are studded dips towards the sutures, causing the latter to be clearly defined. The apical disc is of the same size as the mouth-opening and in the specimen figured is six tenths of an inch in diameter; the plates with which it is furnished are large, and covered with granules; the mouth is furnished with strong jaws, shown in the plate.

"The spines are long, cylindrical, and very slightly tapering, covered with small, strong, equal-sized granules, the points of which project outwards. They are arranged in ten regular longitudinal ridges, with a sulcus between them covered with a very fine granulation. The spiny granules continue to within a tenth of an inch of the collar; the neck is very short and smooth, the head moderately large, cone-shaped, and longitudinally striated with numerous fine lines; the rim of the acetabulum is very finely crenulated. The length of the longest spine, that of the ambitus, is one inch and eight tenths; it is slightly broken at the extremity, and therefore would, if perfect, be rather longer; its diameter is one tenth of an inch; the short spine, which is unbroken (seen in the right hand of the plate), has its extremity suddenly expanded.

"*Affinities and Differences.—Cidaris intermedia*, in the general appearance of its test, closely approaches *C. sceptrifera* and *C. subvesiculosa;* it differs from the former in the scrobicular margins from the ambitus to the peristome being in contact, or not separated by more than one granule,—in the more narrow miliary zone,—in the lesser number of rows

of granules in the ambulacral areas at the ambitus (*C. sceptrifera* in specimens of the same size as that under consideration having eight at the equator, whilst this species has six),—in these granules being more irregularly disposed and more crowded together,—in the proximal discal plate being marked with a more prominent tubercle, and in its shape being less elongated,—in the areolas being relatively larger,—in the spines being uniformly cylindrical instead of fusiform, and of much less diameter,—and in the serrated ridges of the spines being fewer, wider apart, and continuous the whole length, whilst in *C. sceptrifera* some of the ridges cease at the widest part of the spine. *C. intermedia* differs from *C. subvesiculosa* in the scrobicular margins of adjacent plates being less widely separate,—in the granules on the margins of the areolas being more distant,—in the sutures of the miliary zones being less marked,—in the miliary zones being smaller,—in the spines being of less diameter, with less numerous ridges, and apparently shorter (some spines of *C. subvesiculosa*, of a test of equal dimensions, reaching a length of three inches),—and in the plates presenting a flatter and less tumid appearance.

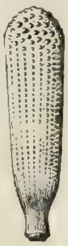
"*Locality and Stratigraphical Position.*—Collected from the White Chalk of Sussex, apparently from the base of the Chalk-with-flints; rare. The specimen figured, Plate XII, fig. 1 *a*, is of the natural size. Fig. 1 *b*, one of smaller spines magnified, length 1 inch, diameter $\frac{1}{10}$th of an inch.

"Additional Notes on *CIDARIS CLAVIGERA*, *König*. (See p. 48.)

"Very marked as are the variations in the general aspect of the spines of *C. clavigera*, it will usually be found that a single and prevailing form is connected with each individual test. On Pl. XIII are drawn the tests and spines (figs. 1 *a*, 3 *a*, 4 *a*) of three specimens, in which the spines attached to the tests are tolerably uniform in shape in each case collectively, yet are dissimilar when viewed by groups, those of fig. 1 *a* being all claviform, those of fig. 3 *a* being all medially constricted, those of fig. 4 *a* being all fusiform. The same remark holds good in other examples not drawn on the plate. I have now before me sixteen specimens of *C. clavigera*, with the spines attached, in all of which specimens, although as a general character each company of spines has a club-shaped or approximately club-shaped contour, there is so great a variableness among the different groups that if in any group the two extremes in form were to be compared apart from the test they could easily be mistaken for different and distinct species; some (No. 1 of the Table on page 72) being wholly cylindrical, these by easy gradations seen in sets of forms passing on so as to become pear-shaped (No. 4), next taking up the ordinary clavigerous type (Nos. 6, 7, 8), and ending with those having the medially constricted outline (No. 10).

"I append woodcuts of some of these varieties, giving their dimensions in tenths of an inch, and also the diameter (major axis) of the test to which they belong. The measurements of the spine in each case have been derived from a specimen which in its natural position would have been affixed to the ambitus.

"Table showing variation of form in the spines of *Cidaris clavigera*.

Ambitus Spine, characteristic of the general form of the whole of the spines attached to any individual test of *C. clavigera*, nat. size.	Total length of longest ambitus spine.	Diameter of spine at neck.	Diameter at greatest thickness.	Length of neck before swelling commences.	Form of apex.	Diameter of test at ambitus.
Almost uniformly cylindrical and slender; very unusual form of spine. 1. 	1·1	·1	·2	·3	Hemispherical.	Uncertain, about 1·0
Almost uniformly cylindrical, but not slender; very rare. 2. 	1·2	·1	·3	·2	Hemispherical.	Uncertain.
Slightly tapering; rare. 3. 	·8	·1	·2	·1	Subacute.	About ·6
Pear-shaped, longitudinal section elliptical; rather rare. 4. 	·9	·2	·4	·2	Subacute.	1·1
Pear-shaped, longitudinal section ovate; rather rare. 5. 	·8	·2	·4	·3	Sub-hemispherical.	1·2

"Table showing variation of form in the spines of *Cidaris clavigera*—continued.

Ambitus Spine, characteristic of the general form of the whole of the spines attached to any individual test of *C. clavigera*, nat. size.	Total length of longest ambitus spine.	Diameter of spine at neck.	Diameter at greatest thickness.	Length of neck before swelling commences.	Form of apex.	Diameter of test at ambitus.
Club-shaped, stem slightly tapering; common. 6. 	1·3	·2	·3	·6	Hemi-spherical.	About 1·6
Club-shaped, stem cylindrical; common. 7. 	1·0	·2	·3	·6	Hemi-spherical.	1·1
Club-shaped, portion nearest the apex constricted; common. 8. 	1·3	·1	·4	·7	Hemi-spherical.	1·1
Club-shaped, portion nearest the apex constricted; rather rare. 9. 	1·0	·1	·2	·4	Hemi-spherical.	·8
Constricted at about half the length; very rare. 10. 	·7	·1	·2	·1	Acute.	·6

"From the above Table it will be seen that this variation in form is independent of the size of the test, and is dependent rather upon some peculiar law in the formation of the spine, or some cause which has contributed to produce a greater development of calcareous matter in one part than in another. In flints which contain the spines of *C. clavigera* a fracture passing through the spine will often exhibit this growth very beautifully; thus, in the woodcuts (fig. 1), whilst an earlier form of the spine is clearly defined, the subsequent addition of material is also manifested by the change of tint. The same effect can also be observed in longitudinal sections of the ordinary spines, a difference of density and of hardness in the whole or parts of the enveloping layers being very apparent.

FIG. 1.

Sections of body-spines of *C. clavigera* in flint.

"In *C. clavigera* the difference between the spines of the peristome and of the ambitus is more marked than in most of the other species of the CIDARIDÆ of the Upper Cretaceous group. The woodcuts (fig. 2) drawn from the spines of the tubercles adjacent to the mouth, and magnified four diameters, show that their apex is more acute, their ridges fewer, and their body more elongate-ovate than in the larger spines of the ambitus. The spines of the granules (fig. 3) are also dissimilar, being longitudinally striated, contracted at intervals, having almost parallel sides, and being in transverse section ovate.

FIG. 2.

Spines of *C. clavigera* from the tubercles adjacent to the peristome; magnified four diameters. One spine has four serrated ridges, the other six.

FIG. 3.

Spine of *C. clavigera* from the granules on the margin of the ambulacral areas; magnified eight diameters.

"The spines in their original condition appear to have been tinted with parallel bands of colour, perpendicular to the axis. In several examples now in my cabinet the apex of the spine shows evidence of this peculiarity; but in one specimen in particular (a test to which the spines are attached) that circumstance is so marked and is so persistent (the base and apex of the body of the spines being specially affected) that it can hardly be the result of accident.

"The common longitudinal perforations in the outer layer of the spine alluded to at p. 50 seem to have been chiefly due to disease or to some difference in structure which caused those parts, now empty, to decay with greater facility in one direction than in

another. A transverse section of spines so affected proves that the canals are of neither uniform length nor dimensions, some being of greater extent and more open than others.

"The central perforation not unusual at the apex of some spines, seems also due to disease or to parasitic borings, and will often be found to extend downwards as far as the acetabulum. This is the case with the spine drawn in Pl. V, fig. 6. A portion of the surface of this spine having been carefully removed subsequent to the drawing being made on the plate, the cavity apparent at the apex was seen to extend through the whole length of the body, unaltered in size; just below this point it suddenly contracted in a circular curve (similar to the base of the perforations made by a *Pholas*) as though to avoid breaking through the walls of the neck; at the lower point of the circular excavation the opening appeared again, only with a very much less diameter, and extended as far as the articular cavity, through which it passed. Another spine open at the apex, when cut lengthways, gave the same result (of a continuous tube, of two different diameters), except that the opening, which extended almost as far as the acetabulum, did not pierce it, but passed outwards in a transverse direction.

"The test of *C. clavigera* varies in the proportions of its parts from youth to age; my smallest example, five tenths of an inch in width, differs considerably in appearance from my largest, which is one inch and seven tenths in width. Comparing these two it is seen that the tubercles in the former are relatively larger than in the latter; that the granules of the miliary zone are in the former almost as large as in the latter; that the number of plates are the same in both; that there is an oval rudimentary tubercle in the uppermost plate of the anal side in the largest specimen; that the areolas of the two superior tubercles of the anal side are in the smallest example separated by only three granules, including those of the scrobicular margin, whilst in the largest example there are fourteen. Both specimens have four rows of granules in the ambulacral areas at the ambitus; in the smallest they are of equal size and equally disposed, in the largest the two interior are much smaller than the two exterior, more numerous, and crowded together. These differences have a tendency to cause the two specimens, when placed with the anal side uppermost, to appear very dissimilar, particularly in the region of the miliary zone. Of these two specimens the smallest is much below and the largest much above the average size.

"Spines of *C. clavigera* are sometimes, but very rarely, found as far down as the middle of the flinty Chalk; the proper horizon of *C. clavigera* is above this part.

"Figures 1 *a*, 1 *b*, 2, 3 *a*, 3 *b*, 3 *c*, 4 *a*, 4 *b*, 5 *a*, 5 *b*, Pl. XIII, are from the Upper Chalk of Bromley, in Kent.

"ADDITIONAL NOTE ON *CIDARIS PERORNATA*, Forbes. (See p. 62.)

"This *Cidaris* is the largest of all the Cretaceous CIDARIDÆ; portions of a full-grown specimen now before me, containing four complete columns of plates in contact, give the following dimensions for the test—height, two inches and two tenths; transverse diameter, two inches and one tenth. The spines, like the body, also exceed those of all other species. In a mass of spines of *C. perornata* from my cabinet, which are all one tenth of an inch in diameter, is one which, although deficient of a portion of its apex, measures in the remaining part of its length four inches and six tenths—this length is by no means a maximum. The number of the plates and the form of the spines appear to have rendered perfect examples of the test with spines attached exceedingly rare. Separate plates and groups of broken spines are plentiful; complete columns of plates uncommon. Small *Ostreæ* are occasionally found affixed to the spines.

"The test, when full-grown, has, in the ambulacral areas, eight rows of granules at the ambitus; of which rows the two exterior are the largest and most evenly disposed, the six interior are more numerous, of less size, and not so regularly arranged; at the mouth-opening there are six rows, at the anal four; the second discal plate has nineteen pairs of pores in the poriferous zone; the proximal discal plate in each column has a rudimentary tubercle and an elongate obsolete areola. The granules of the miliary zone are of two sizes, the smallest of which occupy the spaces between the largest. In specimens of the test of the usual size the first, second, and third of the plates, reckoning downwards from the anal opening, have the upper half of the boss crenulated. The spines belonging to the granules of the scrobicular margins are flat and somewhat fan-shaped; they are covered with minute striæ, which converge from the circular base (in which there is an acetabulum) towards the smaller apex; length two tenths of an inch, greatest width one twentieth. The jaws of a full-grown specimen do not greatly differ in outline from those of other species; they are half an inch in length.

"*Cidaris perornata* is tolerably common in the Upper Chalk; it appears to commence (where it is rare) in the middle of the flinty Chalk.

"ADDITIONAL NOTE ON *CIDARIS DIXONI*, Cotteau. (See p. 67.)

"All the spines of this species hitherto found are of considerable size, and are claviform, and inflated; the apex is acute; the surface covered with numerous granules, which

are large and elongate on the upper half of the body, pointed at the apical region, circular on the lower half of the body, diminishing in area as they approach the neck, and ceasing at that part, arranged in rows gradually increasing in number from the apex to the greatest diameter, and afterwards more closely and less regularly deposited; the neck smooth, short, and very much contracted; the milled ring is slightly prominent, covered with fine longitudinal striæ; the head smooth.

"The spines of *C. Dixoni* occur at the base of the Lower or Grey Chalk in the cliffs between Folkestone and Dover, in the band containing the spinous *Ostrea carinata*, Sow. (M.C., tab. 365, fig. 1), in company with *C. Bowerbankii;* they are, however, very rare. The same species is found occasionally in the "Coprolitic Bed" of Cambridge, a deposit containing rolled fossils from the Lower Chalk, Upper Greensand, and Gault formations. The specimen figured in Pl. XII, fig. 6, and obtained from the Coprolitic Bed of Cambridge, is identical in all respects with the Folkestone examples, except that the surface is more worn, and appears to have been subjected to much friction; the width of the Cambridge specimen is seven tenths of an inch, length of body one inch. The total length of spine (measured from a specimen in perfect condition in my cabinet), from Folkstone is one inch and four tenths; greatest diameter (midway between apex and edge of acetabulum) seven tenths; length of head and neck three twentieths; diameter of neck three twentieths.

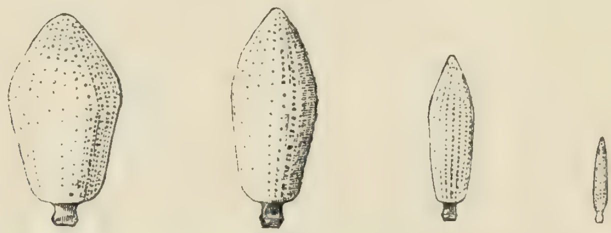
"The test of this *Cidaris* has not at present been discovered; it would appear, however, judging from the analogy of its spines with those of *C. Bowerbankii*, that it must have much in common with the latter, except size; perhaps it may be an aged form of *C. Bowerbankii.*

"Additional Note on *CIDARIS BOWERBANKII, Forbes.* (See p. 45.)

"In this species, as in others of the *Cidares*, the form of the spine varies according to its position on the test; those at the peristome are tolerably cylindrical, with an acute apex; those at the ambitus are inversely conical, with the apex less acute, and those at the anal margin have the body inflated and the apex somewhat obtuse. The peristome spines have the surface covered with coarser granulations than is the case with those which occur on the opposite side. At Southeram Pit, near Lewes, Sussex (Lower Chalk), tests with the spines *in situ* are occasionally found. In my cabinet is a specimen from Southeram Pit nearly perfect, in which almost the whole series of spines, from the anal to the oral region, are in position, and in which the variation of form in these spines, according to their situation, is well exhibited. From this specimen were drawn the figures shown in the woodcuts fig. 4 *a*—*d*, which are twice the size of the originals; *a* is the spine

in connection with the tubercle adjacent to the anal margin; *b* that on the next tubercle, counting downwards; *c* that beneath *b*; and *d* that below *c*, on the tubercle which is the third from the peristome: *a* is in length five tenths of an inch, in diameter three tenths; *d* is in length two tenths of an inch, in diameter one twentieth. The test from which these spines are derived is five twentieths of an inch in height, and nine twentieths in transverse diameter.

FIG. 4.



a. *b.* *c.* *d.*

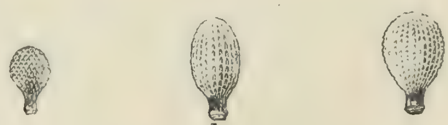
Spines of *Cidaris Bowerbankii;* magnified two diameters.

"Several of the spines of this species from different localities are figured on Pl. XIII; figs. 9, 10, and 11 are from Folkestone, figs. 13 and 14 from Cambridge, 8 from near Arundel, from which last-mentioned locality also come the plates of *C. dissimilis*, figured Pl. XIII, figs. 6 *a*, 6 *b*. In all these a certain variation in general form is very perceptible.

"*Cidaris Bowerbankii* has great affinities in its test with *C. clavigera*, but is always much smaller in size. It is a very rare species. The horizon of *C. Bowerbankii* at Folkestone is just above the Upper Greensand.

"At Folkestone, in company with the spines of *C. Bowerbankii*, occur globose spines with a short neck, and having the body covered with coarse spiny projections arranged longitudinally. They are drawn of the natural size in the woodcut fig. 5; they appear to differ from *C. velifera*, and are perfectly distinct from the spines of *C. Bowerbankii*.

FIG. 5.



a. *b.* *c.*

Spines of a *Cidaris* from the Lower Chalk at Folkestone; natural size.

"ADDITIONAL NOTE ON THE *CIDARES* FROM THE RED CHALK. (See p. 44.)

"In the thin red-coloured band met with at Hunstanton, in Norfolk, and in the lowest of the pink-coloured beds at Speeton, in Yorkshire, occasionally occur elongate, cylindrical

spines, which do not exactly agree with those previously referred to in this Monograph; four of these are drawn on Pl. XII, of which figs. 7, 8, and 9 are from Hunstanton, and fig. 10 from Speeton. They may be divided into three classes—(α) slender, having few (ten to sixteen) longitudinal ridges, with a prickly border, Pl. XII, figs. 7 and 9; (β) thick, having numerous longitudinal ridges, with the prickles almost obliterated, Pl. XII, fig. 10; and (γ) slender, without ridges, but with an occasional projecting prickle.

"The drawing, Pl. XII, fig. 7, represents a magnified view (the natural size being depicted by a black line) of the expanded extremity of a spine with twelve ridges, not unlike in its general character that to be met with in some forms of the spines of *Cidaris Gaultina,* but differing from the latter in the valleys between the ridges being covered with very fine longitudinal lines, instead of being marked with fine granulations. Fig. 9, with ten ridges, is marked also by the fine longitudinal striæ, and the absence of granulations in the valleys; the lines of spiny projections or prickles are thinner, more conspicuous, sharper, and less numerous than in the spines of *C. Gaultina;* it is very slightly tapering; the fragment preserved measures an inch in length, and must when perfect have been at least two inches; in general aspect it bears a strong resemblance to *C. subvesiculosa* from the Upper Chalk.

"The spine fig. 10 *a* (natural size), and fig. 10 *b* (a portion magnified) is found both at Speeton and Hunstanton; the specimen figured, which was from Speeton, and is not quite perfect, measures one inch and a half in length, and is two tenths at its greatest diameter; the body of the spine increases very gently in diameter for a short distance from the acetabulum, and then as gently diminishes; the margin of the acetabulum is crenulated, a double milled ring surrounds the head, the neck is short and smooth, and the body is marked by about thirty longitudinal ridges, which are crowned by small and obtuse spiny projections. The valleys between the ridges are covered with fine longitudinal striæ; the general aspect is that of a spine of *C. dissimilis,* but the latter generally has the spines much more slender.

"Fig. 8, from Hunstanton, is only a fragment, half an inch in length, and one tenth of an inch in diameter; it is uniformly cylindrical, with the surface quite smtooh and without striæ; arising from the smooth surface are stout prickles, like thorns, which are repeated in longitudinal lines at about the distance of the tenth of an inch apart from each other. It is a very peculiar spine, totally distinct from all those of the Cretaceous species, and mostly resembles the spine of *C. perornata* from the Upper Chalk; in the latter, however, the prickles arise from a small longitudinal ridge, and are not isolated and unconnected. The same form of spine occurs at Speeton. In the ratio of frequency, the form α is more common than that of β; and the forms α and β are more common than that of γ, which is very rare."

Family 2.—HEMICIDARIDÆ. (Not yet found in British Cretaceous strata.)

Family 3.—DIADEMADÆ.

This Family includes large and small Urchins having a thin, circular, pentagonal, and subpentagonal test, more or less depressed on the upper surface, and flat at the base.

The ambulacral areas are wide and straight, with two rows of primary tubercles, often as large and numerous as those of the inter-ambulacral areas.

The poriferous zones are narrow, almost always straight, and sometimes subflexuous; the pores are unigeminal, bigeminal, and trigeminal in their arrangement in different genera.

The inter-ambulacral areas are in general twice the width of the ambulacral, and occupied, at the equator, with two, four, six, or eight rows of primary tubercles, which diminish gradually in number near the poles. The bosses of all the tubercles are small; their summits, in general, are crenulated, sometimes uncrenulated; the tubercles are small, in general perforated, in *Cyphosoma* imperforate; they are in general a little larger than those of the ambulacra; but are often of equal magnitude in both areas.

The apical disc is small, and situated opposite to the mouth; it is composed of five ovarial and five ocular plates; the anterior pair of ovarial plates are a little larger than the posterior pair, and the right antero-lateral plate, with a small, spongy, madreporiform body on its upper surface, is the largest; the vent is round or oblong, and generally in the centre of the disc; the ocular plates are very small, and distinguished with difficulty.

The mouth-opening is in general large and decagonal, and the peristome divided into ten lobes by deep notches; the jaws in general are large and powerful.

The spines in existing genera are long, slender, and tubular, sometimes three times as long as the diameter of the test.[1] In the fossil extinct genera they rarely attain the length of the diameter of the test, and are short, stout, and solid, except in *Hemipedina*, which have long hair-like spines. The long tubular spines of living Diademas, and a rare form from the Cretaceous rocks, are encircled by spiral verticellate processes, or fringe-like scales, Pl. XIV, fig. 2, whilst the surface of the solid spines of Pseudodiademas is in general covered with fine longitudinal lines; neither prickles or asperities being developed on their stems.

Lamarck divided the genus *Cidaris* of Klein into two sections, "*Les Turbans*" and "*Les Diadèmes*;" these were afterwards by Dr. Gray[2] erected into genera; the *Cidaris radiata*, Leske, constituting a third type, formed his new genus *Astropyga*. The genus *Cidarites* of Lamarck was considered to form a natural family, including the genera *Cidaris*, *Diadema*, and *Astropyga*, which he constituted and characterised thus:—

[1] PETERS, 'Ueber Gruppe der Diademen,' p. 2, 101. Königl. Akademie der Wissenchaften Augt., 1853, Berlin.

[2] 'Annals of Philosophy,' new series, vol. x, p. 426, 1825. "An attempt to divide the Echinidæ or Sea-Eggs into natural families."

1. *Family*—Cidaridæ. *Cidarites*, Lamarck.

Body with spines of two sizes; larger ones either club-shaped or very long; spine-bearing tubercles perforated at the summit.

Genus 1—Cidaris, *Klein*, *Lamarck*. (Les Turbans.)

Body depressed, spheroidal; ambulacra waved; small spines compressed, two-edged, two-rowed, covering the ambulacra, and surrounding the base of the larger spines.

This genus may be divided according to the form of the larger spines: the extra-ambulacral beads have only two rows of spines.

Cidaris imperialis, *Lamk.* Klein., Nat. dispositio Echinodermatum, tab. vii, fig. a.

Genus 2—Diadema, *Gray*. (Les Diadèmes.)

Body orbicular, rather depressed; ambulacra straight; spines often fistulous.

Echinometra setosa, *Rumph.* Leske, Klein., Nat. disp. Echinid., tab. xxxvii, fig. 1, 2.
Echinus diadema, *Linn.* Syst. Nat., by Turton, vol. iv, p. 139.
— calamaria, *Pallas.* Spicil. Zool., tab. ii, fig. 4—8.

Genus 3—Astropyga, *Gray*.

Body orbicular, very much depressed; ambulacra straight; ovarial scales very long, lanceolate; beads with several series of spines.

Cidaris radiata, *Leske*, apud *Klein*, tab. xliv, fig. 1.

The very meager characteristics by which Dr. Gray has defined the last two genera merely shows that a difference exists, and his description is insufficient for a correct diagnosis of either; hence the various opinions extant regarding the character and limits of his genus *Diadema;* only one of the species enumerated as types, *Diadema setosa*, Rumph.,

is admitted to be a true *Diadema.* The valuable memoir of Herr W. Peters[1] has removed some of the difficulties that surrounded this subject, and his grouping of the living Diademas makes an important step towards a natural classification of one section of this Family. Although the present state of our scientific knowledge of the *Diademadæ* may be considered as transitional rather than positive, still we possess enough to justify the separation of fossil Diademas from existing genera, as proposed by M. Desor.[2]

The Diademadæ, in fact, appear to consist of two types; one of these, with a few rare exceptions, appertains to the present epoch, the other existed during the deposition of the Secondary and Tertiary rocks. The living forms are in general large, depressed Urchins, with thin shells, having the tubercles and pores variously arranged in the different genera. They have, in general, very long, slender, *tubular* spines, and the surface of the stem is covered with oblique annulations of small imbricated scales. The fossil species, on the contrary, are smaller Urchins, with a thicker test; having the tubercles and pores variously disposed in different genera; the spines rarely attain the length of the diameter of the test; they are in general *solid,* cylindrical, sometimes flattened or awl-shaped, and their surface is covered with fine longitudinal lines. I propose to include the following genera in this natural family.

A Table showing the Classification of the Diademadæ.

DIADEMADÆ	*Section* A. Spines very long, slender, tubular, covered with oblique annulations of imbricated scales. Living in tropical seas. A few annulated tubular spines are found in the Upper Chalk and in the Coralline Crag.	Diadema, *Gray.* Savignya, *Desor.* Astropyga, *Gray.* Echinothrix, *Peters.*
	Section B. Spines short, slender, solid; surface covered with fine longitudinal lines. Extinct; found in the Oolitic, Cretaceous, and Tertiary Rocks.	Pseudodiadema, *Desor.* Cyphosoma, *Agassiz.* Hemipedina, *Wright.* Pedina, *Agassiz.* Echinopsis, *Agassiz.*

My learned friend M. Cotteau,[3] in his classical work on the Echinidæ of France, has lately proposed an extended classification of the family Diademadæ, a *résumé* of which I

[1] 'Ueber die Gruppe der Diademen, Konigl. Akademie der Wissenschaften,' Berlin Aug., 1853.

[2] 'Synopsis des Échinides Fossiles.'

[3] 'Paléontologie Française, Terrain Crétacé,' tom. vii, p. 371.

herewith subjoin; the genera referred to this family are divided into four groups, based upon the structure of the tubercles, whether they are perforated or not perforated, and crenulated or not crenulated.

In the Cidaridæ these characters have not much significance, and are present or absent in many species of congeneric forms; in the Diademadæ, however, they are more stable and persistent, and have served to form a great number of genera. If from an organic point of view this structure of the tubercles is only of secondary importance, in a palæontological sense it affords a character which is readily seen, and nearly always well preserved.

The first group comprehends the Diademadæ[1] with tubercles perforated and crenulated: *Hemicidaris*, Agassiz; *Acrocidaris*, Agassiz; *Pseudodiadema*, Desor; *Diadema*, Gray; *Hibertia*, Michelin; *Microdiadema*, Cotteau; *Heterodiadema*, Cotteau; *Asterocidaris*, Cotteau; *Glyphocyphus*, Haime.

The second group includes the genera with tubercles perforated and not crenulated: *Cidaropsis*, Cotteau; *Diademopsis*, Desor; *Hemipedina*, Wright; *Echinopsis*, Agassiz; *Orthopsis*, Cotteau: *Pedinopsis*, Cotteau.

The third group is destined to receive the genera which have the tubercles imperforated and crenulated: *Cyphosoma*, Agassiz; *Micropsis*, Cotteau; *Temnopleurus*, Agassiz; *Echinocyphus*, Cotteau.

The fourth and last group contains the genera with tubercles imperforated and uncrenulated: *Goniopygus*, Agassiz; *Acropeltis*, Agassiz; *Leiosoma*, Cotteau; *Echinocidaris*, Desmoulins; *Cœlopleurus*, Agassiz; *Kœraiaphorus*, Michelin; *Codiopsis*, Agassiz; *Cottaldia*, Desor; *Magnosia*, Michelin; *Glypticus*, Agassiz; *Temnechinus*, Forbes; *Opechinus*, Desor.

The genera which compose these four groups are distinguished by straight or flexuous ambulacra, the disposition of the tubercles, the structure of the apical disc, the sutural and angular impressions which mark the ambulacral and inter-ambulacral plates, the comparative width of the peristome, and the form and structure of the spines.

The following table contains a definition of the opposable characters of the thirty-one genera composing the family Diademadæ.

[1] In my classification of the Echinidæ I have separated *Hemicidaris* and *Acrocidaris* as a distinct family, the Hemicidaridæ.

A. Tubercles crenulated and perforated.

a. Ambulacral areas subflexuous, provided with large tubercles at the ambitus and inferior surface . . . . HEMICIDARIS.

b. Ambulacra straight, provided with tubercles in all their extent.

X. Ambulacral and inter-ambulacral plates without angular impressions.

x. Inter-ambulacral areas subgranular as they approach the summit.

y. Apical disc subpentagonal, peristome large.

z. Each of the ovarial plates of the apical disc carry a large tubercle . ACROCIDARIS.

zz. Apical disc, without a large tubercle on its ovarial plates.

1. Poriferous plates unequal and irregular.

φ. Spines solid, aciculated, striated . . . . PSEUDODIADEMA.

φφ. Spines tubular, verticillated . . . . DIADEMA.

2. Poriferous plates straight, equal, regular . . . . HIBERTIA.

yy. Apical disc narrow, annular, peristome reentrant . . MICRODIADEMA.

yyy. Apical disc elongated, prolonged into the middle of the single inter-ambulacral area; peristome narrow . . . HETERODIADEMA.

xx. Inter-ambulacra smooth near the summit, and presenting a stellate appearance . . . . . . ASTERIOCIDARIS.

XX. Ambulacral and inter-ambulacral plates marked with angular impressions . GLYPHOCYPHUS.

B. Tubercles perforated and not crenulated.

a. Ambulacra subflexuous, provided with tubercles only towards the ambitus and inferior surface . . . . CIDAROPSIS.

b. Ambulacra straight, provided with tubercles in all their extent.

X. Pores simple near to the summit.

x. Ambulacral plates unequal, irregular.

y. Apical disc largely developed, peristome wide.

z. Miliary zone extended; principal inter-ambulacral tubercles very large, placed on the external border of the plates . . . DIADEMOPSIS.

zz. Miliary zone narrower, tubercles tolerably large and placed in the middle of the plates . . . . . . HEMIPEDINA.

yy. Apical disc narrow, peristome slightly developed, tubercles very small. ECHINOPSIS.

xx. Ambulacral plates, straight, regular, sutures very apparent . . ORTHOPSIS.

XX. Pores in double series at the superior surface and towards the ambitus . PEDINOPSIS.

C. Tubercles not perforated and crenulated.

a. Ambulacral and inter-ambulacral plates without angular impressions.

x. Form depressed, tubercles rather large, peristome widely open . . CYPHOSOMA.

xx. Form inflated, tubercles small, peristome narrow . . . MICROPSIS.

b. Ambulacral and inter-ambulacral plates marked with angular, and sutural impressions.

x. Apical disc sub-circular, inter-ambulacral tubercles forming many rows towards the ambitus . . . . . TEMNOPLEURUS.

xx. Apical disc pentagonal, inter-ambulacral tubercles forming two rows . ECHINOCYPHUS.

D. Tubercles not perforated and not crenulated.

a. Ambulacral and inter-ambulacral plates without angular and sutural impressions.

x. Apical disc smooth, ovarial and ocular plates perforated below at their external angle . . . . . . GONIOPYGUS.

xx. Apical disc furnished with a large tubercle on each ovarial plate; ovarial and ocular plates perforated at some distance from the border . ACROPELTIS.

xxx. Apical disc granular, deprived of tubercles; ovarial and ocular plates perforated at some distance from the border.

x. Tubercles rather large, forming regular vertical rows.

y. Two rows only of inter-ambulacral tubercles; mammelon large and prominent . . . . . . LEIOSOMA.

yy. More than two rows of inter-ambulacral tubercles; mammelon small . ECHINOCIDARIS.

yyy. Inter-ambulacral tubercles not extending above the ambitus; inter-ambulacral area forming, at the upper part, a depressed zone, perfectly circumscribed.

z. Four rows of inter-ambulacral tubercles towards the ambitus . CŒLOPLEURUS.

zz. Two rows of inter-ambulacral tubercles towards the ambitus; spines long, sub-tricarinated, and slightly bent . . . KÆRAIAPHORUS.

yyyy. Ambulacral and inter-ambulacral tubercles limited to the inferior surface, replaced above the ambitus by caducous granules . . CODIOPSIS.

xx. Tubercles small, forming very regular horizontal rows.

y. Peristome small, pores simple towards the ambitus . . COTTALDIA.

yy. Peristome very wide, sub-pentagonal, pores forming double rows from the ambitus to the mouth . . . . MAGNOSIA.

D. Tubercles not perforated and not crenulated—*continued.*

yyy. Inter-ambulacral tubercles irregularly arranged above the ambitus, often lacerated . . . . GLYPTICUS.

b. Ambulacral and inter-ambulacral plates provided with angular and sutural impressions.

x. Impressions angular . . . . . TEMNECHINUS.

xx. Impressions sutural, and angular, and much more defined . . OPECHINUS.

The stratigraphical distribution of the Diademadæ extends from the Trias to the modern epoch, where a few species now live in tropical seas. Of the thirty-one genera enumerated in the above table, seven are proper to the Oolitic period: *Microdiadema, Asterocidaris, Cidaropsis, Hemipedina, Acropeltis, Glypticus.* Seven to the Cretaceous period: *Heterodiadema, Glyphocyphus, Orthopsis, Pedinopsis, Echinocyphus, Leisoma, Codiopsis.* Five are special to the Tertiary period: *Hibertia, Echinopsis, Cœlopleurus, Temnechinus, Opechinus.* Three to the Modern period: *Diadema, Echinocidaris,* and *Kæraiaphorus.* One genus, *Pseudodiadema,* is common to the Oolitic, Cretaceous, and Tertiary periods. Three genera are found in the Oolitic and Cretaceous periods; *Hemicidaris,* which commenced in the Trias, *Acrocidaris* and *Magnosia,* but neither extend above the Neocomian. Four genera are common to the Cretaceous and Tertiary periods: *Goniopygus, Cottaldia, Cyphosoma,* and *Micropsis.* The genus *Temnopleurus* appeared in the Tertiary period and exists in our present seas.

PSEUDODIADEMA, *Desor.* 1854.

This genus is composed of small Urchins with a moderately thick test, which rarely attains two inches in diameter; the ambulacral areas in general are one third or even one half the width of the inter-ambulacral areas; the primary tubercles of both areas are perforated, and nearly all of the same size; the bosses are small, and have sharply crenulated summits.

The ambulacral areas have two rows of tubercles; the inter-ambulacral areas two rows only, or two rows of primary and two or four short rows of smaller secondary tubercles, or they have four, or six rows of nearly equal-sized primary tubercles at the ambitus.

The poriferous zones in general are narrow and straight; the pores in one section are unigeminal throughout, and in another they are bigeminal in the upper part of the zones. The apical disc is small; and the anterior ovarial plates are larger than the posterior pair.

The mouth-opening is large, the peristome deeply notched, and the oral lobes are nearly equal.

The spines rarely attain the length of the diameter of the test; in general they are much shorter, cylindrical, or needle-shaped, and have a prominent, milled ring near the articulating head; the rim of the acetabulum is crenulated, and the socket perforated; the surface of the stem is sculptured with delicate longitudinal lines.

The *Pseudodiademata* are all extinct, and found in the Liassic, Oolitic, Cretaceous and Tertiary rocks.

Pseudodiadema differs from *Diadema* in having solid spines, with a smooth surface, the sculpture, in most cases, consisting of microscopic, longitudinal lines; whilst in *Diadema* the spines are tubular, and have oblique annulations of scaly fringes on their surface. *Pseudodiadema* differs from *Cyphosoma*, a Cretaceous genus, in having the tubercles always perforated, those of *Cyphosoma* being imperforate. It differs from *Hemipedina* in having a small apical disc, and tubercles with crenulated bosses, those of *Hemipedina* being smooth; and from *Pedina* in having the pores unigeminal or bigeminal, those of *Pedina* being arranged in triple, oblique pairs.

Pseudodiadema may be divided into two sections, from the different manner the pores are arranged in the zones. In one group the pairs of pores form a single file throughout; in another the pores are more numerous, and crowded together in the upper part of the zones. Professor M'Coy has proposed the genus *Diplopodia* for the latter. It may be objected, however, that the crowding together of a greater number of pores in a zone is, at most, a sectional and not a generic character, inasmuch as the arrangement is subject to great variation in the diplopodous species themselves, and is, moreover, often only an adult development.

A.—*Species from the Lower Greensand.*

PSEUDODIADEMA ROTULARE, *Agassiz.* Pl. XIV, figs. 3 *a*, *b*, *c*.

DIADEMA ROTULARE, *Agassiz.* Mém. des Sc. nat. de Neuchâtel, vol. 1, p. 139, tab. xiv, figs. 10—12, 1836.
— — *Des Moulins*, Études sur les Échinides, p. 316, No. 25, 1837.
— ORNATUM, *Agassiz.* Catal. Syst. Ectyp. foss. Musei Neoc., p. 8, 1840.
— ROTULARE, *Agassiz.* Descript. des Échin. foss. de la Suisse, part 2, p. 4, tab. xvi, fig. 1—5, 1840.
— MACROSTOMA, *Agassiz.* Ibid., p. 10, tab. xvi, fig. 22—26, 1840.
— ROTULARE, *Agassiz* et *Desor.* Catal. Raison. des Échinides, Ann. des Sc. nat, 3e série, t. vi, p. 346, 1846.
— MACROSTOMA, *Agassiz* et *Desor.* Ibid., p. 347, 1846.
— — *Bronn.* Index Palæontologicus, p. 418, 1846.
— CORONA, *Gras.* Oursins foss. de l'Isère, p. 33, pl. i, fig. 21—23, 1848.
— ROTULARE, *Marcou.* Recherch. géol. sur le Jura Salinois, Mém. Soc. Géol. de France, 1re série, t. iii, p. 143, 1848.

DIADEMA ROTULARE,	*D'Orbigny.* Prod. de Paléont. Strat., t. ii, p. 89; Ét. 17, No. 489, 1850.
— MACROSTOMA,	*D'Orbigny.* Ibid., No. 491, 1850.
— ROTULARE,	*Cotteau.* Cat. Éch. Néocom., Bull. Soc. de l'Yonne, t. v, p. 285, 1851.
DIADEMA DUBIUM,	*Sharpe.* Sands and Gravels of Farringdon, Quart. Journ. Geol. Soc., vol. x, p. 194, 1853.
— —	*Forbes.* In Morris's Catalogue of British Fossils, 2nd ed., p. 76, 1854.
— ROTULARE,	*Cotteau.* Paléontologie Française, Ter. Cretacè, vol. vii, p. 422, pl. 1097, figs. 11—13; pl. 1098 and 1099.
PSEUDODIADEMA —	*Desor.* Synopsis des Échinides fossiles, p. 69, 1856.
— MACROSTOMA,	*Desor.* Ibid., p. 68.
— ROTULARE,	*Cotteau.* Études sur les Échinides de l'Yonne, t. ii, p. 24, pl. xlix, figs. 1—5, 1857.
— PIETETI,	*Cotteau.* Ibid., p. 31, pl. l, figs. 7—10, 1857.
— TRISERIALE,	*Desor.* Synop. des Échin. foss., p. 445 (Suppl.). 1858.
— ROTULARE,	*Dujardin* et *Hupé.* Hist. Nat. des Zoophytes, Échinoderm., p. 428, 1862.
— PERIQUETI,	*Dujardin* et *Hupé.* Ibid.
— MACROSTOMA,	*Dujardin* et *Hupé.* Ibid.
— TRISERIALE,	*Dujardin* et *Hupé.* Ibid.

Test small, circular, slightly pentagonal, moderately convex above, and flat below; poriferous zones narrow, straight; pores in single file; ambulacral areas large, two rows of close-set marginal tubercles; inter-ambulacral areas, four rows of tubercles at the ambitus, the outer rows disappearing on the upper surface; miliary zone wide, depressed near the disc, and covered with an abundance of well-formed granules. Mouth-opening large, decagonal; peristome deeply notched; lobes unequal.

Dimensions.—Height four tenths of an inch; transverse diameter, one inch.

Description.—This is a very rare Urchin from the remarkable deposit of fossiliferous sands and gravels near Farringdon in Berkshire, about the age of which so many different opinions have been given; perhaps the Echinidæ found therein may assist to determine the problem whether these beds belong to the Lower Greensand, or to a "more modern member of the Cretaceous Series than the Chalk," as maintained by the late Mr. Daniel Sharpe, F.G.S.[1] The Diadema now before us is a well-known and characteristic species, of the middle stage of the Neocomian formation, containing *Echinospatagus cordiformis;* and the extensive table of synonyms prefixed to this article shows how widely it is distributed in beds of the same age on the continent of Europe.

The test is of medium size, circular or slightly pentagonal, moderately convex on the upper surface, and nearly flat beneath.

[1] "On the Age of the Fossiliferous Sands and Gravels of Farringdon and its Neighbourhood," 'Quart. Journ. of the Geological Society,' vol. x, p. 176. 1853.

The ambulacral areas are wide (fig. 3 *a*, *b*) and have two rows of tubercles placed on the margin of the area; these are small, uniform in structure, set closely together, and gradually diminish from the equator to both poles; a band of granulations down the middle of the area divides the two series from each other: the poriferous zones are narrow and straight (fig. 3 *b*); the pores are round and simple, and arranged in a single file throughout the zones (fig. 3 *c*).

The inter-ambulacral areas are occupied at the ambitus by four rows of tubercles; the inner rows extend from the mouth to the disc, and the outer rows diminish in size on the upper surface and disappear before reaching the disc; the tubercles forming the inner row are about the size of those in the ambulacra; those of the outer row are sensibly smaller (fig. 3 *b*). The miliary zone is large, and slightly depressed near the summit; it is filled with numerous granules of unequal sizes, some of which are mammillated and perforated; the granules are disposed in circles around the areolæ, and fill the entire area of the zones with a beautiful ornamentation; the examples from Farringdon have lost much of this character from the process of fossilization in those gravel beds.

The base of the test is flat, and presents a highly tubercular surface (fig. 3 *a*), the four rows of tubercles in the inter-ambulacral areas being all distinctly developed in this region. The mouth-opening, one half the diameter of the test, is proportionally large; the peristome is deeply notched into the lobes, the ambulacral portions being one half larger than those of the inter-ambulacral arches. In fig. 3 *c*, I have given a section of the base, magnified four diameters, showing the relation of all these parts to each other.

Affinities and Differences.—This Urchin presents many varieties of form, which have been described by different authors as so many distinct species, an error that has been now corrected, as shown in the table of synonyms. It resembles *P. Bourgueti*, Ag., found with it in the same Neocomian beds, but is distinguished from that species in having the primary tubercles less developed, more closely set together, and more homogeneous; and in the secondary or outer series of tubercles being larger and more regularly arranged; they are, however, nearly allied forms of one type of structure.

Locality and Stratigraphical Position.—This Urchin in England has hitherto been found only in the sands and gravels near Farringdon, where it is extremely rare. It was collected from these beds by the late Mr. D. Sharpe, and I obtained one specimen in the same locality. On the continent of Europe it is one of the most characteristic fossils of the "Terrain Néocomien," and is found principally in the middle beds of that formation. M. Cotteau records the following localities in France where it has been collected:—Billecul, Miéges, et l'ermitage de Censeau, Nozeroy (Jura); Morteau, Hautepierre (Doubs); Germigney (Haute-Saône); Vassy, Bettancourt, (Haute-Marne); Thieffrain, Vandœuvre, Marolles (Aube); Cheney, Flogny, Moneteau, Auxerre, Gy-l'Éveque, Leugny, Fontenoy, Saints, Pereuse (Yonne); in all these localities it is collected in abundance from the Middle Neocomian; and at Le Rimet (Isère), Villefargeau, Perrigny (Yonne), it is very rare in the Upper Neocomian. In Switzerland it is found near Locle in the Lower

Neocomian; and at Landeron, Sainte-Croix, Hauterive in the Middle Neocomian, so that it forms a leading fossil of the Neocomian formations.

History.—This Urchin was at first referred by Professor Forbes to the *Diadema dubium* of Albin Gras, but a careful comparison of specimens proved this to be an error. It appeared under that name in Mr. Sharpe's list of Echinodermata from the sands and gravels of Farringdon, and in the second edition of the 'Catalogue of British Fossils.'

Pseudodiadema Fittoni, *Wright.* Pl. XV, Figs. 1, *a*—*g*.

Diadema Autissiodorense, *Wright.* Ann. and Mag. of Nat. History, New Series, vol. x, p. 91, 1852.

Test pentagonal, depressed; inter-ambulacral areas with two rows of primary tubercles and two incomplete series of small secondary tubercles, which disappear on the upper surface; ambulacral areas prominent, with two rows of primary tubercles much diminished in size at the upper surface; poriferous zones narrow, subflexuous. Pores bigeminal near the ovarial disc, and at the circumference of the mouth.

Dimensions.—Height four tenths of an inch; transverse diameter nineteen twentieths of an inch.

Description.—In its general outline this beautiful Urchin resembles *P. depressum* of the Inferior Oolite; in the details of structure, however, it is very distinct from that form. The circumference is pentagonal, from the convexity of the ambulacral areas, and the upper and under surfaces are much depressed (Pl. XV, fig. 1 *a*, *b*, *c*, *d*).

The inter-ambulacral areas are one third broader than the ambulacral; two rows of primary tubercles occupy the centre of the plates; there are about ten pairs of tubercles in each area, which are of a moderate magnitude, and gradually diminish in size from the ambitus to the base and summit; the mammillary eminences are small, their summits sharply crenulated, and the tubercles, of proportional size, are deeply perforated (fig. 1 *g*); at the ambitus six rows of granules separate the tubercles from each other (fig. 1 *e*); towards the upper part of the miliary zone the four central rows are absent, leaving a naked space in the middle of the area; three rows of granules in like manner separate the tubercles from the poriferous zones; at the base of the area, and extending as far as the ambitus, there are incomplete rows of small secondary tubercles; these gradually diminish in size, and disappear at the upper surface, which is occupied with an unequal close-set granulation about three rows deep (fig. 1 *b*); the ambulacral areas, one third narrower than the inter-ambulacral, are very prominent and convex, and occupied by two rows of primary tubercles about ten in a row; the lower six pairs of tubercles are nearly as large as the corresponding tubercles in the inter-ambulacral areas, but the upper

four pairs are much smaller, so that, whilst there is a great uniformity in the size and form of the tubercles at the base and ambitus of the test, there is a very marked difference between those of the ambulacra and inter-ambulacra in the vicinity of the apical disc (fig. 1 *b*); the inter-tubercular space is occupied by a zigzag band of granulation, which is narrow below where the tubercles are large, and broader above where they are small (fig. 1 *e*). The poriferous zones are narrow and subflexuous; and the pores arranged in single pairs; near the disc they are slightly bigeminal; the apical disc is absent in our specimen. The mouth-opening is large and the peristome slightly decagonal (fig. 1 *c*).

Affinities and Differences.—*Pseudodiadema Fittoni* nearly resembles *P. Bourgueti*, Ag., but differs from it in the rudimentary condition of the upper tubercles of the ambulacra, and in having the intermediate granulation on the miliary zone less homogeneous.

Locality and Stratigraphical Position.—I collected this Urchin from the Lower Greensand at Atherfield, in bed No. 4 of the Cracker group, Dr. Fitton's section; it must be very rare, as none of the cabinets of Atherfield fossils hitherto examined by me contain a specimen.

History.—I discovered this fossil in 1850, and in the first instance erroneously identified it with a specimen found in France, and then briefly described by M. Cotteau as *Diadema Autissiodorense.* The fine figures and detailed description lately published by M. Cotteau in his additions to the "Paléontologie Française" have enabled me to correct my error, and I now dedicate this species to the memory of my late friend Dr. Fitton, F.R.S., whose admirable memoir on the Atherfield section and the strata below the Chalk will long remain models of patient research and accurate scientific investigation.

PSEUDODIADEMA MALBOSI, *Agassiz & Desor.* Pl. XX, figs. 1, *a*—*f*.

DIADEMA MALBOSI,	*Agassiz* and *Desor.* Catal. rais. des Échinides, Ann. Science. Nat., 3me sér., t. vi, p. 350, 1846.
— —	*D'Orbigny.* Prodrome de Paléont. strat., t. ii, p. 201, 1850.
DIPLOPODIA —	*Desor.* Synops. des Échinides fossiles, p. 78, pl. xii, figs. 12—14, 1856.
— —	*Leymerie* et *Cotteau.* Catal. des Échinid. Foss. des Pyrenées, Bullet. Soc. Géol. de France, 2e sér., t. xiii, p. 324, 1856.
DIADEMA MACKESONI,	*Forbes.* Woodward's Notes on British fossil Diadems, Mem. Geol. Surv., Decade V, 1856.
— MACKIEI,	*Woodward.* Ibid.
— MALBOSI,	*Pictet.* Traité de Paléont., 2e éd., t. iv, p. 245, 1857.
DIPLOPODIA —	*D'Archiac* les Corbières. Mém. Soc. Géol. de France, 2e sér., t. vi, p. 384, 1859.

Diplopodia Malbosi, *Dujardin* et *Hupé.* Hist. Nat. des Zooph. Échinodermes, p. 501, 1862.
Pseudodiadema Malbosi, *Cotteau.* Échinid. Foss. des Pyrenées, p. 26, 1863.
— — *Cotteau.* Paléontologie Française, Ter. Crétacé, tom. vii, p. 448, pls. 1106 et 1107, 1865.

Test large, subcircular, upper surface convex, slightly inflated, base rounded and flattened, ambulacral areas narrow, contracted at the upper part by the width of the poriferous zones, two rows of tubercles twenty to twenty-two in each row. Inter-ambulacral areas wide with four, six, or eight rows of tubercles at the equator, the two inner rows having eighteen to twenty tubercles in each, extend from the peristome to the disc, all the others disappear at different points on the sides. Small secondary tubercles scattered irregularly among the primary series in the inferior part of the areas. Poriferous zones narrow at the base and sides; pores in double file from the ambitus to the disc, where they increase in width, and on the upper third are largely bigeminal. Mouth-opening moderate in size; peristome nearly equal lobed; discal opening large and acutely pentagonal.

Dimensions.—Transverse diameter two inches; height thirteen twentieths of an inch.

Description.—This is a very rare British Urchin, and as nearly all the tests have been either broken, crushed, or otherwise distorted, it is difficult to form a correct idea of its form. I have carefully examined the original specimens collected by Mr. Mackeson, F.G.S., from the Lower Greensand at Hythe, and presented by him to the Royal School of Mines; these I have compared with a series collected by my friend the Rev. T. Wiltshire, from the Lower Greensand at Whales' Chine, Isle of Wight, with which they agree, and both correspond with the figures and description of *Pseudodiadema Malbosi* given by M. Cotteau in the 'Paléontologie Française,' and with a good type specimen kindly presented to me by M. Bayle, of the École des Mines, Paris. I have no hesitation, therefore, in considering *D. Mackesoni*, Forb., identical with *D. Malbosi*, Agass. It is important likewise to note that both belong to the same geological horizon; the French specimens were collected from the Upper Neocomian, associated with *Echinospatagus Collegnii*, Sism., and the British specimens from the Lower Greensand at Hythe, and the Crioceras-beds, Lower Greensand, at Whales Chine, Isle of Wight, the English equivalent of the Continental Neocomian formation.

This Urchin attains a considerable size; Mr. Wiltshire's cabinet contains a specimen measuring two and a half inches diameter. The base of this fossil is nearly circular, and only slightly pentagonal. In some of the Hythe specimens in the Museum of the Royal School of Mines, the upper surface is convex and moderately inflated, and the base rounded and flattened.

The ambulacral areas are narrow and contracted at their apices by the width of the poriferous zones above (fig. 1, *g*); they are slightly inflated, and furnished with two

rows of large tubercles, from twenty to twenty-five in each, according to the size of the Urchin, all deeply crenulated and perforated, and gradually diminishing from the equator to the apertures; a single sinuous line of granules separates the tubercles, which are placed closely together in the area (fig. 1 *d*).

The poriferous zones are narrow at the base and sides, where the pores are arranged in a single file (fig. 1 *e*); at the upper part they are bigeminal (fig. 1 *d*), the double rows encroaching on the width of the ambulacral area and diminishing the size of the tubercles therein.

The poriferous plates are prolonged to the base of the tubercles in more or less apparent irregular sutures (fig. 1 *d*).

The inter-ambulacral areas are widely developed, the large plates support tubercles closely resembling those of the ambulacra (fig. 1 *g*). In the figured specimen there are six rows at the equator, and in larger specimens there are eight distinct rows. The two internal rows have eighteen tubercles a little larger than the others, extending from the peristome to the disc; the other rows have a more limited range, and disappear on the upper surface. It is only in the largest specimens that eight rows are found at the ambitus, the tubercles of the shorter rows being a little less than those of the two internal series (fig. 1 *g*); besides the primary tubercles a number of small secondary tubercles are crowded along each side of the median suture, between the peristome and the ambitus, and others occupy spaces by the side of the poriferous zones. The miliary zone is wide, smooth, and depressed at the upper surface; the granules are irregularly scattered on its lower half, and some of them are even developed into small mammillated tubercles on the upper surface; they form hexagonal circlets around the areas of the primary tubercles; the median suture is very well defined, and lies in a smooth depression of the test (fig. 1 *a*, *c*).

The mouth-opening (fig. 1 *b*) is large and pentagonal, and the peristome divided into lobes of unequal sizes; the arches that span the ambulacra are longer than those of the inter-ambulacra.

The apical disc was very large; the opening is pentagonal and acutely angular, the angles extending far into the median suture of the inter-ambulacra (fig. 1 *a* and *g*).

The spines are slender, and circular; above the milled ring of the head, there is a short portion of the stem ornamented with fine longitudinal lines (fig. *f*), whilst the portion beyond is entirely smooth. I have represented this character in the fragment fig. 1 *f*.

M. Cotteau has figured a large example of this species from the Upper Neocomian; from this we learn that age produces important modifications in the structure of the test; the poriferous zones are very wide, and bigeminal, not only on the upper surface, but as far down as the ambitus; besides the eight rows of primary tubercles there are some rudiments of secondary tubercles; the miliary zone is wide and depressed at the upper surface; the discal opening becomes more angular, and the ovarial plates penetrate

further into the ambulacral areas ; the mouth-opening is circular, and the peristome nearly equally lobed.

Affinities and Differences.—*Pseudodiadema Malbosi* resembles some of the larger forms of *P. Brongniarti,* from the Grey Chalk of Folkestone, in the cabinet of my friend the Rev. T. Wiltshire, and figured in Pl. XX, fig. 2 *a, b,* in Pl. XXI B, fig. 3, and Pl. XXI A, fig. 2. The tubercles in *P. Brongniarti* are not so numerous in each row; the poriferous zones are narrower, and the bigeminal arrangement of the pores, so well developed in *P. Malbosi,* is less distinct in *P. Brongniarti.* These certainly are nearly allied species, and require a careful examination to detect the small differences existing between them.

P. Malbosi resembles *P. dubium*, Gras, from the same horizon. I have only a mould in plaster of the latter, not sufficiently sharp for scientific accuracy.

Locality and Stratigraphical Position.—The specimens I have figured were collected from the Lower Greensand at Whales Chine, Isle of Wight, in the Crioceras-beds that pass across that chasm, associated with *Ammonites Martini*, D'Orb., *Crioceras Bowerbankii*, Sow., *Gryphæa sinuata*, Sow., &c.

The specimens in the Museum of the Royal School of Mines were collected by Mr. H. B. Mackeson, from the Lower Greensand (Kentish Rag) of Hythe, and presented by him to that institution. Specimens are extremely rare in both the places quoted.

The foreign localities, according to M. Cotteau, are La Classe (Aude), Opoul (Pyrénées Orientales), where it is abundant in the Upper Neocomian beds, associated with *Echinospatagus Collegnii*, D'Orb.

B.—*Species from the Gault.*

PSEUDODIADEMA WILTSHIREI, *Wright*, nov. sp. Pl. XVI, figs. 1 *a—f,* 2, 3.

Test moderately large and equally depressed at both poles; ambulacral areas wide, with two rows of tubercles, large and approximated in the lower half of the area, small and detached in the upper; poriferous zones narrow, flexuous, pores in single file throughout; inter-ambulacral areas narrow, two rows of primary tubercles, and a few irregular secondary tubercles at the base of the area, primaries large and approximated in the lower half, small and remote above; miliary zone wide and finely granulated above, narrow and with large granules below; spines long and slender, the stem ornamented with delicate longitudinal lines.

Dimensions.—Height six tenths of an inch; transverse diameter an inch and a half.

Description.—We only possess a fragment of this beautiful form, still it has been enough to enable Mr. Bone to give a restoration of the test in Pl. XVI, fig. 1 *b.* The body is inflated at the sides, and nearly equally flattened on the upper and lower surface. The

ambulacral areas are wide and have two rows of tubercles; those on the lower portion of the area are large and closely set together, and those on the upper part are disproportionately small and placed widely apart (fig. 1 *b*); some very fine granules divide the large basal tubercles, and a numerous granulation surrounds the smaller tubercles on the upper part (fig. 1 *b*).

The inter-ambulacral areas possess only two rows of primary tubercles; those near the base are about the same size as the corresponding tubercles in the ambulacra, on the upper part of the area, they are larger, and diminish more gradually in size, so that the difference in the tubercles on the upper surface readily distinguishes the ambulacral from the inter-ambulacral areas; an irregular row of four small secondary tubercles occupies the outer side of the base between the primaries and the poriferous zones, and a like central row extends through the middle of the lower part thereof (fig. 1 *c*).

The miliary zone is wide and depressed in the upper part, and the plates are here covered with numerous small granules, that cluster chiefly around the bases of the small tubercles, the median sutural space being depressed and nude (fig. 1 *b*); the lower part of the zone is narrow, and the granules are much larger and more closely set together; many of them are raised on small mammillons, with secondary tubercles interspersed among them (fig. 1 *c*).

The large primary tubercles of both areas have very large areolas (fig. 1, *c*), with well defined margins. Each areola consists of two parts, an outer circle, consisting of a band covered with microscopic granules (fig. 1 *d*), and a smooth inner portion, from whence the boss arises (fig. 1 *e*). This kind of ornamention is very remarkable; it is very well preserved in the fragment before me, and correctly represented in figs. *d* and *e*. The summit of the boss is sharply crenulated, and the tubercle deeply perforated.

The spines were long and slender, as seen by some imprints on the slab (figs. 1, 2, 3); the acetabulum of the small head is marked by coarse crenulations, the milled ring is prominent, and the whole surface of the stem covered with fine longitudinal lines.

Affinities and Differences.—This species belongs to the group of which *P. Normaniæ* (Pl. XXI, fig. 3) may be regarded as the type. It differs from that species, however, in having smaller primary tubercles and fewer and smaller secondaries, in having narrower ambulacra and less flexuous poriferous zones. The miliary zone is likewise less distinctly marked; the general contour of the test is different, for the upper and lower surfaces are more depressed and the sides less inflated.

Locality and Stratigraphical Position.—This unique specimen was found by the Rev. T. Wiltshire, F.G.S., in the Gault at Folkestone, in a bed near the base of that formation. I have very great pleasure in dedicating this species to my kind friend as an acknowledgment of the important assistance he has rendered me during the progress of this work, by the generous contribution of all his best specimens for figuring, his able notes on certain species of Cidaris, and other valuable aid frankly given on all occasions when required.

c.—*Species from the Upper Greensand.*

Pseudodiadema Rhodani, *Agassiz*. Pl. XVIII, figs. 3 *a—e*.

Diadema Rhodani,	*Agassiz*. Cat. Syst. Ectyp. foss., Mus. Neoc., Supplement, 1840.
— Lucæ,	*Agassiz*. Idem, Mus. Neoc., p. 8.
— Rhodani,	*Agassiz*. Desc. des Échinid. foss. de la Suisse, tom. ii, p. 9, pl. xvi, figs. 16—18, 1840.
— Lucæ,	*Agassiz*. Idem, p. 8, pl. xvi, figs. 11—15, 1840.
— —	*Agassiz* and *Desor*. Cat. Raison. des Échinid., Ann. des Science Nat., 3e sér., t. vi, p. 346, 1846.
— Rhodani,	*Agassiz* and *Desor*. Idem.
— Lucæ,	*Bronn*. Index Palæontologicus, p. 418, 1848.
— Rhodani,	*Bronn*. Idem, p. 419.
— lucæ,	*Albin Gras*. Oursin. foss. de l'Isère, p. 33, 1848.
— —	*D'Orbigny*. Prodrome de Paléontol. strat., t. ii, p. 142, Ét. 19, 1850.
— Rhodani,	*Renevier*. Mém. Géol. sur la Perte du Rhone, p. 49, 1853.
— —	*Morris*. Catalogue of British Fossils, 2nd ed., p. 70, 1854.
— —	*McCoy*. Mesozoic Radiata, p. 67, 1854.
Pseudodiadema Lucæ,	*Desor*. Synopsis des Échinides fossiles, p. 71, 1855.
— Rhodani,	*Desor*. Idem, p. 71.
Diadema —	*Pictet*. Traité de Paléontol., 2e ed., t. iv, p. 244, 1857.
— Lucæ,	*Pictet*. Idem.
— Desori,	*Forbes*. Notes by S. P. Woodward; Memoirs of the Geol. Surv., Decade V, p. 8, 1856.
— pustulatum,	*Forbes*. Idem, p. 8, 1856.
Pseudodiadema Lucæ,	*Dujardin* et *Hupé*. Hist. Nat. des Zoophytes, Échinodermes, p. 498, 1862.
— Rhodani,	*Dujardin* et *Hupé*. Idem.
— —	*Cotteau*. Paléontol. Française, Terrain Crétacé, p. 460, pl. 1110, 1864.

Diagnosis.—Test circular, depressed, slightly convex above, very concave beneath, a little inflated at the angles; ambulacral areas with two complete rows of tubercles, fourteen to fifteen in each, and three incomplete rows of small secondary tubercles at the base, five or six in each; inter-ambulacral areas with two rows of primary tubercles, thirteen or fourteen in each, and four rows of small unequal secondary tubercles at the base; primary tubercles large at the ambitus, suddenly diminishing in size in both areas on the

upper and under surface; plates covered with a fine uniform granulation; mouth-opening situated in a concave depression.

Dimensions.—Transverse diameter one inch and one tenth of an inch, height half an inch.

Description.—Although this Diadema exhibits a group of well-marked specific characters, its history, nevertheless, is involved in much confusion, from want of a careful examination of the anatomy of the shell.

The prominent ambital tubercles in the inter-ambulacra, their sudden diminution in size on the upper surface, with the baldness of the test in that region, and the crowding of the base with small tubercles nearly uniform in size, form a group of persistent characters which distinguish *Pseudodiadema Rhodani* from all its congeners.

The smaller forms of this species were figured and described by Professor Agassiz as *Diadema Lucæ*, and the large tests as *Diadema Rhodani*. A series of specimens, of different ages, has since shown that these two forms are identical.

This initial error introduced the confusion that followed, and has rendered it a matter of some difficulty to understand the synonyms of this species; the careful study of a good type form sent by the late M. Sæmann from the Gault (Étage Albien, d'Orbigny) of Clars, near Escragnolle, department of the Var, has enabled me to compare our English examples with an undeniable specimen, and from this examination to determine that *Diadema Desori*, Forb., and *D. pustulatum*, Forb., are different forms of *Pseudodiadema Rhodani*. My late esteemed colleague Dr. S. P. Woodward adopted Professor Forbes's materials in his "Notes on British Fossil Diadems," contributed to Decade V of the 'Memoirs of the Geological Survey;' and it is evident from these notes that he had his doubts as to the accuracy of our lamented friend's determinations, as will appear in the description of the different species.

There are two varieties of *Pseudodiadema Rhodani*—a large form, identical with the type, figured by Agassiz,[1] and a smaller form, corresponding with *P. Lucæ*. The former I have obtained from the Chloritic Marl of Chard; the latter from the Upper Greensand of Warminster, where it appears to be rare. The fine example figured in Pl. XVIII, fig. 3, *a, b, c,* is of moderate size; the test is circular and depressed, slightly convex above, inflated at the sides, and very concave below; the ambulacral areas are large, and a little expanded at the sides to give increased space to the ambital tubercles; from this point they taper regularly towards both poles. There are two rows of primary tubercles, from sixteen to seventeen in each, extending from the peristome to the disc; three of these in each row, at the ambitus, are large, and all those on the upper surface small, diminishing to mere granules near the disc (fig. 3 *a*); the tubercles on the under surface are small, and have a uniform size to the peristome; in this region the area is filled in with several smaller secondary tubercles (fig. 3 *b*). The poriferous zones are slightly undulated at the

[1] 'Description des Échinodermes fossiles de la Suisse,' tab. xvi, figs. 16—18, p. 9.

sides and base; they are composed of simple oval pores arranged in single file throughout (fig. 3 *d*). The inter-ambulacral areas one half wider than the ambulacral, have two rows of primary tubercles, fourteen to fifteen in each; a little larger at the ambitus and upper surface than in the ambulacra; three pairs are much larger at the sides, those on the upper surface diminish rapidly in size between the ambitus and disc; and on the under surface they are small and nearly uniform in structure. Between the basal angle and the peristome there are short rows of secondary tubercles, about the size of the primaries in this region, with a few scattered secondaries between the lateral rows; as all these small tubercles are nearly the same size, the under surface of the test has a highly ornamented appearance—the inter-ambulacra with four, and the ambulacra with two rows of small, uniform tubercles, and several secondary ones planted at every interval on the plates (fig. 3 *b*). On the upper surface the six upper tubercles are small, diminishing to mere granules around the discal opening (fig. 3 *c*). The large ambital tubercles are surrounded by shallow circular areolas (fig. 3*d*). In some specimens they are confluent, in others separated by one or two rows of minute granules. The small dorsal tubercles are surrounded by ring-like areolas, and the basal tubercles have a chain-like arrangement of granules encircling them, which adds to the ornamentation of this region. The miliary zone is very large; from the sides to the discal aperture the entire surface of the plates of both areas, except those portions occupied by the areolas, is covered with small, numerous, close set of granules, which form divisional partitions on each side of the mesial sutures between the rows of the primary tubercles, and then expand into a regular corrugation on all the upper surface, the dwarfing of the tubercles being compensated by an increased development of granular ornamentation on this region of the test. The base is very concave, and the small, circular peristome, indented with well-marked entailles, is situated at the bottom of a deep depression; the entire surface of the base is studded with small tubercles, surrounded with the circles of granules already described. The disc is absent in all the specimens hitherto found; the opening is large and pentagonal, indicating a great development of this structure in the species.

Affinities and Differences.—*P. Rhodani* is readily distinguished from its congeners by the subundulated poriferous zones, small dorsal, intermediate basal, and large primary ambital tubercles, by the shortness of the secondary rows limited to the base, by the smallness of the dorsal tubercles and the fine homogeneous granulation on the miliary zone; the concavity of the base, smallness of the peristome, and depth at which it lies, added to the highly ornamented character of the plates, form a group of characters that readily distinguish it from all others. It resembles most *P. Normaniæ* (Pl. XXI, fig. 3), from the Grey Chalk of Folkestone, in the varied development of the tubercles in each row; the *ensemble* of the test in the latter form is sufficiently defined by good specific characters, and for the definition of these I must refer to the article on that species.

Locality and Stratigraphical Position.—The large example I have figured was found

in the Chloritic Marl, full of green specks of iron, at Chard, associated with *Catopygus carinatus*, Goldf., *Discoidea subuculus*, Leske, *Pseudodiadema ornatum*, Goldf., *P. variolare*, Brong., with *Ammonites splendens*, Sow., *A. varians*, Sow., and other forms characteristic of the Upper Greensand formation. The specimens from Warminster, in the Museum of the Royal School of Mines, and in the Collections of Mr. Soper and Mr. Cunnington, Devizes, were found in the Upper Greensand with *P. Michelini*, Agas., and *P. Benettiæ*, Forb., and other common Upper Greensand forms, as *Catopygus carinatus*, Goldf., *Salenia petalifera*, Agass., and *Goniopygus peltatus*, Agas., &c. &c.

Foreign Distribution.—Geraudot (Aube); Pérte du Rhône (Ain); Clars, Escragnolle (Var); very common in the Étage Albien (Cotteau).

History.—First figured by Professor Agassiz in 1840, the large forms as *Diadema Rhodani*, the smaller as *D. Lucæ*. After much confusion it was discovered that these forms are identical. Professor Forbes, from not possessing types of *Pseudodiadema Rhodani*, named the large form *Diadema pustulatum*, and the small ones from Warminster *D. Desori*; this nomenclature was adopted by Dr. S. P. Woodward, in 1856, in his "Additional Notes on British Fossil Diadems," published in Decade V of the 'Memoirs of the Geological Survey.' M. Cotteau, in 1863, has given admirable figures, and a most correct description of the species, which my observations confirm in all their details.

PSEUDODIADEMA MICHELINI, *Agassiz*. Pl. XIX, figs. 2, *a—f*.

DIADEMA MICHELINI,	*Agassiz*. Catal. Syst. Ectyp. foss. Mus. Neoc., p. 8, 1840.
— —	*Agassiz* et *Desor*. Catal. rais. des Échinides, Ann. Sc. Naturelles, 3e sér., t. vi, p. 347, 1846.
— —	*Bronn*. Index Palæont., p. 418, 1848.
— —	*Sorignet*. Ours. foss. de dép de l'Eure, p. 25, 1850.
— —	*D'Orbigny*. Prod. Paléont. strat., t. ii, p. 179, 1850.
— BONEI,	*Forbes*. In Morris's Catalogue of British Fossils, 2nd ed., p. 76, 1854.
— —	*Woodward*. Mem. of Geol. Survey, Decade V, explan. of pl. ii, 1856.
PSEUDODIADEMA MICHELINI,	*Desor*. Synopsis des Échinides fossiles, p. 72, 1856.
DIADEMA MICHELINI,	*Pictet*. Traité de Paléont., 2e éd., t. iv, p. 245, 1857.
PSEUDODIADEMA PULCHELLUM,	*Cotteau*. Échinides nouv. ou peu connus (Revue de Zoologie), p. 3, pl. i, fig. 7—9, 1857.
PSEUDODIADEMA MICHELINI,	*Dujardin* et *Hupé*. Hist. Nat. des Zoophytes, Echinoderm., p. 499, 1862.
— —	*Cotteau*. Paléontologie Française, Terrain Crétacé, p. 476, pl. 1114, 1864.

Diagnosis.—Test circular, or slightly pentagonal, depressed; base flat, inflated at the margin, concave towards the mouth; ambulacral areas large, two rows of prominent

primary tubercles, 12—14 in each row; interambulacral areas with two rows of primary tubercles, 12—14 in a row, and two external rows of small secondary tubercles, extending from the peristome to the ambitus; mouth-opening small, in a concave depression; tubercles of both areas nearly the same size.

Dimensions.—Height six tenths of an inch; transverse diameter one inch and one fifth.

Description.—This Urchin is in general of medium size, with a sub-circular or pentagonal test, convex above and flat below; the ambulacral areas are large, slightly inflated, and provided with two rows of small primary tubercles, 12—14 in a row, rather less than those in the interambulacral areas, and separated by a double zigzag row of very small granules (fig. 2 *d*), gradually diminishing in size from the ambitus to both poles; the poriferous zones are subflexous and composed of pairs of small round holes placed in single file throughout, crowded together near the peristome, and spread out above; the inter-ambulacral areas are twice the width of the ambulacral and furnished with two rows of primary tubercles rather larger than those of the ambulacral areas; they are very uniform in size and gradually diminish from the ambitus to the poles; between these rows and the poriferous zones, and between the two rows themselves, a series of small tubercles, 6—8 in number, extends from the peristome to the ambitus, where they disappear; these small secondary tubercles fill up the intertubercular spaces at the base, and give the under surface of the test a very ornamental appearance (fig. 2 *b*). There are fourteen plates in each column of the inter-ambulacra, the primary tubercle occupying the centre of each; the areolas are circular and superficial, the bosses prominent and sharply crenulated, and the mammillons large and deeply perforated (fig. 2 *d*); the surface of the plates is sparsely covered with small granules which form circles around the areolas and are scattered without order over the interspaces; the internal borders of the four uppermost plates of both columns are nude (fig. 2 *b*); and the sutures distinctly visible throughout their entire course. The ambulacral areas have fourteen plates in each column, the tubercles are rather smaller than those in the inter-ambulacra, and the narrow areolas are separated by a zigzag line of single granules (fig. 2 *f*), which becomes double (fig. 2 *d*) near the ambitus. The miliary zone is large, nude, and depressed at the upper part, granular towards the equator, and narrow and sinuous as it approaches the peristome (fig. 2 *c*).

The mouth-opening is small, and lodged in a deep depression, the basal portion of the test being inflated around the peristome, which is decagonal, with nearly equal lobes (fig. 2 *b*).

The apical disc is absent in all the specimens I have examined; the opening, however, is large, a little elongated, subpentagonal, and angular (fig. 2 *a*).

Affinities and Differences.—This Urchin is distinguished from its congeners by its inflated base, depressed upper surface, simple pores, numerous primary tubercles nearly uniform in size and number in the columns of both areas, by its small unequal secondary tubercles,

extending at the base between the primaries and the poriferous zones, and by its narrow peristome sunk in a deep depression; a careful comparison of typical specimens of *Diadema Michelini*, Ag., from the Upper Greensand of Villers-sur-Mer, Calvados, kindly sent by M. Michelin, has satisfied me that *Diadema Bonei*, Forb., is identical with *D. Michelini;* and that *P. Benettiæ*, Forb. (Pl. XV, fig. 2), both as regards its general form, the number, disposition, and character of its primary and secondary tubercles, the smallness of the mouth-opening, situated in a deep depression, and the equal lobes of the peristome, is identical with some forms of *P. Michelini* of the same size.

Locality and Stratigraphical Position.—This species is very common in the Upper Greensand near Warminster; the smaller forms are very closely allied to the *Diadema Benettiæ*, Forb., the larger to the *D. Bonei*, Forb.; it has likewise been found in the same formation at Durdle Cove, Dorset.

Foreign Localities.—It has been collected from the Étage Cénomanien of France (= Upper Greensand) at Villers-sur-Mer, Cauville, Vaches-Noires, Saint-Jouin (Calvados); Octeville (Manche); Fécamp, Orcher, Le Havre, Rouen (Mont-St.-Catherine), Seine-Infér.; Vimoutiers, Gracè (Orne); Présagny (Eure).

PSEUDODIADEMA BENETTIÆ, *Forbes*. Pl. XV, figs. 2, *a—f*.

DIADEMA BENETTIÆ, *Forbes*. Morris, Cat. Brit. Foss., 2nd ed., p. 76, 1854.
— — *Woodward*. Memoirs of the Geol. Surv., Decade V, p. 7, 1856.
PSEUDODIADEMA BENETTIÆ, *Desor*. Synopsis des Échinides fossiles, p. 72, 1858.
— — *Dujardin* et *Hupé*. Hist. Nat. des Zoophytes, Échinodermes, p. 499, 1862.
— MICHELINI, *Cotteau* (pars). Paléontologie Française, Terrain Crétacé, p. 476, 1864.

Test circular, inflated, depressed; ambulacral areas wide, with two rows of tubercles 15 in each, separated by a double row of minute granules; inter-ambulacral areas with two rows of primary tubercles, 14 in each; separated by a wide median space, unequally granulated; miliary zone smooth above; a few small secondary tubercles at the base; primary tubercles of both areas nearly of the same size. Peristome very small, deeply sunk in a concave depression; discal aperture large and pentagonal.

Dimensions.—Transverse diameter one inch; height four tenths of an inch.

Description.—This beautiful little Urchin was formerly considered to be the *Diadema ornatum*, Goldf., and recorded as such in the first edition of Morris's 'Catalogue of British Fossils.' It was subsequently considered by Professor Forbes to be a distinct species, and in the second edition of that work was dedicated by him to the late Miss

E. Benett, of Norton House,[1] Wilts. It was first accurately described by the late Dr. Woodward in his Notes on Fossil Diadems.

The test is circular, depressed on the upper surface, concave below, and inflated at the sides. The ambulacral areas are proportionally wide, with two rows of tubercles separated by a double row of granules ; there are from 12—15 in each row, according to age; they increase gradually in size, from the peristome and disc towards the ambitus, where they are largest; the poriferous zones are narrow and slightly undulated; the pores are in oblique single file throughout, three pairs of holes being opposite each ambulacral plate (fig. 2 *a*), where they are magnified four diameters; the pores at the circumference have a small tubercle between each pair; the inter-ambulacral areas are about one fourth part wider than the ambulacral; they have two rows of tubercles, from 12—14 in each, separated by a wide miliary zone, which is unequally granulated, and becomes smooth on the upper surface; a similar sparsely granulated space separates the tubercles from the poriferous zones; and at the base of the area a short row of small secondary tubercles extends from the peristome to the angle, between the large tubercles and the poriferous zones. The tubercles of both areas are nearly of the same size, those of the inter-ambulacral are the largest; they have all distinct oval areolas, which are sometimes radiated, and encircled by rows of very small granules. The base is inflated at the circumference, and concave in the middle; the peristome is small and deeply sunk, about one third the diameter of the test; its margin is divided by feeble entailles. The disc is absent in all our specimens; the aperture is wide and pentagonal, the angles pointing towards the median suture of the inter-ambulacral areas.

Affinities and Differences.—This species so much resembles *Pseudodiadema Michelini*, Ag., that it has been considered by some authors to be the same. M. Cotteau says, "*P. Michelini*, such as we understand it, cannot be distinguished from *P. Benettiæ*, Forb., and we do not hesitate to unite the two species, which present in their form, in the disposition of their tubercles, in the structure of their peristome, in a word, in the ensemble of their characters, an identity almost complete." Admitting, as I do, the great similarity of the tests of the two forms, still I think, by a careful study of both, we can detect characters which may justify us in retaining our lamented colleague's species. *P. Benettiæ* has the tubercles smaller, the sides more inflated, the circumference of the base more convex, and the mouth-opening smaller and lodged in a deeper depression. *P. Michelini* is a flatter Urchin, and the size and greater prominence of the tubercles impart to it a more spinous character; if these points of difference in the test are borne out by any corresponding difference in the spines, the species may be sustained; if not, *P. Bennetiæ* may turn out to be a mere variety of *P. Michelini.*

Locality and Stratigraphical Position.—This is a very abundant species in the junction-beds of the Upper Greensand at Warminster, associated with *P. Michelini*,

[1] Authoress of 'A Catalogue of Wiltshire Fossils,' 1831.

Catopygus carinatus, and the other species of this zone. It has been collected from the same beds at Durdle Cove, on the Coast of Dorset.

Foreign Distribution.—M. Desor states that *P. Benettiæ* is found in the Craie chloritée (Cénomanien) of Villers-sur-Mer, Vaches-noires, de Gacé, Orne, and is common in all French collections.

D. *Species from the Grey Chalk.*

PSEUDODIADEMA ORNATUM, *Goldf.*, sp. Pl. XVI, figs. 4 *a—e*; Pl. XIX, figs. 1 *a—c*; Pl. XXI, figs. 1 *a—d*, 2; Pl. XXI A, figs. 1 *a*, *b*.

CIDARITES ORNATUS,	*Goldfuss.* Petref. Germaniæ, tab. xl, fig. 10, p. 123, 1826.
DIADEMA ORNATUM,	*Agassiz.* Prod. d'une Monogr. des Radiares, Mém. Soc. des Sc. Nat. de Neufchatel, t. i, p. 118, 1836.
— —	*Desmoulins.* Études sur les Échinides, p. 314, No. 15, 1837.
— —	*Dujardin.* In Lamarck's Anim. sans Vertébres, 2e éd., t. iii, p. 392, 1840.
— —	*Roemer.* Norddeutschen Kreidegebirges, p. 29, 1840.
— —	*Agassiz* et *Desor.* Catalogue raison. des Échinides, Ann. Sc. Nat., 2e sér., t. vi, p. 347, 1846.
— —	*Bronn.* Index Palæont., p. 449, 1848.
— —	*D'Orbigny.* Prod. de Paléont. strat., t. ii, p. 169, Ét. 20, No. 560, 1850.
— —	*Forbes.* In Morris's British Fossils, 2nd ed., p. 77, 1854.
— —	*McCoy.* Contributions to Brit. Palæontology, p. 67, 1854.
— —	*Desor.* Synopsis des Échinides fossiles, p. 72, 1856.
— —	*Woodward.* Mem. of Geol. Surv., Decade V, p. 7, 1856.
— TUMIDUM,	*Woodward.* Mem. Geol. Surv., Decade V, 1856.
— CARTERI,	*Woodward.* Ibid.
PSEUDODIADEMA ORNATUM,	*Pictet.* Traité de Paléontol., 2e éd., t. iv, p. 245, 1857.
— —	*Dujardin* et *Hupé.* Hist. Nat. des Zoophytes, Échinod., p. 499, 1862.
— —	*Cotteau.* Paléontologie Française, Terrain Crétacé, pl. 1115, tom. ii, p. 480, 1864.

Test circular, inflated; ambulacral areas straight; tubercles small, numerous, subequal, in two rows, separated by a double series of granules; inter-ambulacral areas with two rows of tubercles, separated by four rows of granules at the ambitus, which disappear at the upper surface, and leave a smooth depressed space in the middle of the miliary zone, bordered by two rows of granules; between the tubercles and poriferous zones a row of secondary tubercles extends from the peristome to near the disc, consisting of small well-spaced-out tubercles, each surrounded by a circle of granules. Areolas circular, many of them radiated; tubercles of both areas nearly equal in size.

Dimensions.—Height half an inch; transverse diameter one inch and two tenths.

Description.—This beautiful Urchin when full grown is moderately large; it has a circular, elevated, and inflated form, depressed on the upper surface, and concave beneath.

The ambulacral areas are large, a little inflated, and furnished with two rows of moderately sized tubercles, 14—16 in a row; one of these is always longer than the other, and separated from its fellow by a double series of small compact granules. The poriferous zones are straight and narrow at the base of the test, and gently subundulated from the ambitus to the apical disc; they are composed of simple pores closely approximated to each other; the pairs are well spaced out in the infra-marginal region, closer together at the equator, and still closer placed near the disc. Pl. XXI, figs. 1 *b*, *c*.

The inter-ambulacral areas are large, and provided with two rows of tubercles, nearly identical in size with those of the ambulacral areas at the base and ambitus of the same regions; in the upper part of the area, however, they are proportionally larger, so that we find only 13—15 tubercles in each row. The secondary tubercles form a distinct series of from seven to nine small tubercles, situated between the primary row and the poriferous zones; in general one small tubercle arises from each plate between the peristome and ambitus (Pl. XIX, fig. 1 *d*), and is absent from the three or four upper plates of the test (Pl. XVI, fig. 4 *e*); besides these, there are other smaller tubercles, of unequal size, scattered between the primary and secondary rows (Pl. XIX, figs. 1 *b*, *c*, *d*).

The miliary zone is very wide; it is narrow near the peristome, enlarged at the ambitus, and nude and depressed on the upper surface (Pl. XVI, figs. 4 *c* and *e*). The granules are numerous, unequal, sometimes mammillated, and distinguished with difficulty from the small secondary tubercles among which they are interspersed (Pl. XXI, figs. 1 *a*, *c*; Pl. XVI, figs. 4 *c*, *d*).

The primary tubercles of both areas have well-defined circular areolas, prominent bosses, with sharply crenulated summits, and large mammillons with deeply drilled summits; the inter-ambulacral are a little larger than those of the ambulacral areas. The areolas near the ambitus are mostly confluent above and below, whilst on the upper surface of the inter-ambulacra they are distinct, and surrounded by circles of small granules (Pl. XXI, fig. 1 *c*.).

The under surface is convex at the circumference, with a deep depression in the middle, in which the mouth-opening is situated. The peristome is very small, and its margin feebly indented. The discal opening is large, elongated, and sub-pentagonal. Unfortunately, all the specimens hitherto found want the discal plates (Pl. XIX, fig. 1 *b*).

Affinities and Differences.—This Urchin resembles *P. Michelini;* it is, however, distinguished from that species by its much greater height, inflated sides, narrow base, slightly undulated poriferous zones, more numerous and better developed secondary tubercles, more deeply sunk peristome, and elongated discal opening; these diagnostic characters are not the result of age, as they are observed more or less in comparing young specimens of both species apparently of the same age with each other.

Locality and Stratigraphical Position.—The specimens figured, from the Grey Chalk, Folkestone, on Pls. XVI, XIX, and XXI A, belong to the Rev. T. Wiltshire, the

British Museum, and my cabinet. I have examined a specimen from the Red Chalk of Hunstanton Cliff, belonging to my friend C. B. Rose, Esq., F.G.S., who has most kindly communicated many of his Echinodermata for this work. The specimen figured in Pl. XXI, fig. 1, now in my cabinet, was collected from the remarkable bed of Chloritic Marl at Chard, which has yielded so many fine examples of *Echinidæ*. The specimen in the Cambridge Museum is recorded by Professor McCoy as having been collected from the Upper Greensand of Blackdown. Many of the specimens sent me as *P. Carteri* by my friend Mr. J. Walker, F.G.S., and collected by him from the coprolite beds of the Upper Greensand near Cambridge, are undeniable specimens of *P. ornatum.*

Foreign Distribution.—France.—Rouen, Mountain of St. Catherine, Seine-Inférieure; Vimoutiers (Orne), in the Étage Cénomanien, where it is rare. *Germany.*—Essen-on-the-Ruhr, Westphalia, whence Goldfuss's type specimen was obtained.

History.—This Urchin was first figured and described in the 'Petrefacta Germaniæ' by Goldfuss, in 1826, under the name *Cidarites ornatus.* Professor Agassiz, in 1836, erroneously referred to this species a small Neocomian form, which was subsequently separated under the name *Diadema Bourgueti.* In the first edition of the 'Catalogue of British Fossils,' *Diadema Benettiæ* was recorded as *D. ornatum* on the authority of Dr. Woodward. Professor Forbes named the tumid varieties of this Urchin *Diadema tumidum,* and under this name they are described, from type specimens, in my cabinet (Pl. XXI, fig. 1), by Dr. S. P. Woodward, in his "Notes on British Fossil Diadems," contributed to Decade V, 'Memoirs of the Geological Survey.'

PSEUDODIADEMA NORMANIÆ, *Cotteau,* 1863. Pl. XXI, fig. 3, *a, d.*

PSEUDODIADEMA NORMANIÆ, *Cotteau.* Paléontologie Française, Terrain Crétacé, t. vii, p. 468, pl. 1112.

Test of moderate size, subcircular, inflated at the sides, and convex above; base rounded at the margin, and very concave in the centre; ambulacral areas wide, with two rows of tubercles, large at the ambitus and small on the upper and infra-marginal regions, separated by several rows of minute unequal granules; inter-ambulacral areas narrow, with two rows of primary tubercles, nearly similar in size and development to those of the ambulacra, and numerous small, unequal, secondary tubercles, forming in the infra-marginal region six short series, two on each side, and two in the middle of the primary rows; mouth-opening lodged in a deep depression.

Dimensions.—Height six tenths of an inch; transverse diameter one inch and four tenths.

Description.—This rare and beautiful Urchin is of medium size; it has a subcircular form, with broad inflated sides, convex at the upper surface and very concave beneath. The ambulacral areas are wide in the middle, lanceolate in the upper part, and narrow in the infra-marginal region; they have two rows of primary tubercles, of which two pairs at the

ambitus are very largely developed, and occupy the greatest part of the area, having large areolas, prominent bosses, sharply crenulated summits, with projecting, deeply perforated mammillons (Pl. XXI, fig 3 *d*); on the upper surface they rapidly diminish in size; four of them have small areolas and the others become mere granules. In the infra-marginal region they gradually diminish as they approach the peristome, where two short rows of secondary tubercles are regularly arranged. The primary tubercles are separated by two rows of very fine granules, which gradually increase in number, and fill the entire upper portion of the area (fig. 3 *d*).

The poriferous zones are narrow and straight at the base, undulated on the sides, and straight again on the upper surface; the pores are simple, round, largely open, and arranged in a single file throughout (fig. 3 *c* and *d*).

The inter-ambulacral areas are relatively small from the excessive width of the ambulacra; they have two rows of primary tubercles, of which three pairs at the ambitus, like those in the ambulacral areas, attain a great development; above they become suddenly smaller, and diminish to mere granules; and on the infra-marginal region they become gradually smaller as they approach the peristome. The secondary tubercles are very abundant, and limited to this region of the test; at the base of each interambulacra there are six short rows, a long and a short row between the zones and the tubercles on each side, and two short rows between the tubercles themselves. This great profusion of small secondary tubercles and diminished size of those in the primary series impart to the base of the test of this Urchin a remarkable ornamental appearance, which resembles, on a larger scale, the structure of the base in *P. Rhodani* (fig. 3 *b*).

The miliary zone is largely developed; the two primary rows of tubercles at the ambitus have six rows of granules forming a band between them; in the upper part the granulation increases, and fills the whole zone, except the part occupied by the areolas of the small rudimentary tubercles, forming circles around them, and filling the whole space with a fine nearly uniform granulation.

The base is very concave and crowded with small tubercles; the mouth-opening is small, and lies at the bottom of a very deep depression; the peristome is narrow, and marked by feeble indentations.

Affinities and Differences.—This remarkable species resembles *P. Rhodani* in having its base crowded with numerous small tubercles, and in having large tubercles at the ambitus, and rudimentary ones on the upper surface. Its form, however, is always inflated; the poriferous zones are straight at the base and upper surface, and undulated at the ambitus. The secondary tubercles are larger and more numerous, and distinguished with difficulty from those of the primary rows of the under surface.

Locality and Stratigraphical Position.—The only specimen I have seen was obtained from the Grey Chalk near Folkestone by the Rev. T. Wiltshire, to whose cabinet it belongs.—*Foreign Distribution.*—M. Cotteau records Vimoutiers (Orne), in the Étage Cénomanien, where it is very rare.

PSEUDODIADEMA VARIOLARE, *Brongniart*, sp., 1822. Pl. XVII, figs. 1—5; XVIII, figs. 1, 2.

CIDARITES VARIOLARIS,	*Brongniart.* Géog. phys. des env. de Paris, pl. v, fig. 9, 1822; Tableau des Terrains, p. 408, 1829; Desc. géol. des env. de Paris, 3e édit., pl. xvii, fig. 9, 1835.
DIADEMA VARIOLARE,	*Agassiz.* Prod. d'une Monogr. des Radiaires, p. 189, 1836.
CIDARITES VARIOLARIS,	*Roemer.* Norddeutschen Kreidegebirges, p. 29, 1840.
DIADEMA VARIOLARE,	*Morris.* Catalogue of British Fossils, p. 51, 1843.
— —	*Agassiz* et *Desor.* Catalogue rais. des Échinides, Ann. des Sc. Nat., 3e sér., t. vi, p. 350, 1846.
— SUBNUDUM,	*Agassiz* et *Desor.* Ibid.
— ROISSYI,	*Agassiz* et *Desor.* Ibid.
TETRAGRAMMA VARIOLARE,	*Bronn.* Index Palæontologicus, p. 1261, 1848.
DIADEMA —	*A. Gras.* Oursins foss. de l'Isère, p. 33, pl. ii, fig. 16, 1848.
— SUBNUDUM,	*D'Orbigny.* Prod. de Paléont. strat., t. ii, p. 179, 1850.
— ROISSYI,	*D'Orbigny.* Ibid., t. ii, p. 201.
TETAGRAMMA SUBNUDUM,	*Sorignet.* Ours. foss. de l'Eure, p. 26, 1850.
CIDARIS VARIOLARIS,	*D'Archiac.* Hist. des progrès de la Geol., t. iv, p. 215, 1851.
DIADEMA VARIOLARE,	*Quenstedt.* Handbuch der Petrefaktenkunde, p. 580, 1852.
TETRAGRAMMA —	*Giebel.* Deutschlands Petrefacten, p. 319, 1852.
DIADEMA SUBNUDUM,	*Forbes.* In Morris's Catalogue of British Fossils, 2nd ed., p. 77, 1854.
— VARIOLARE,	*Forbes.* Ibid.
DIPLOPODIA VARIOLARIS,	*Desor.* Synopsis des Échinides fossiles, p. 78, 1856.
— SUBNUDA,	*Desor.* Ibid.
— ROISSYI,	*Desor.* Ibid.
DIADEMA VARIOLARE,	*Woodward.* Mem. Geol. Survey, Decade V, 1856.
— SUB-NUDUM,	*Woodward.* Ibid.
— —	*Pictet.* Traité de Paléont., 2e éd., t. iv, p. 245, 1857.
— ROISSYI,	*Pictet.* Ibid.
DIPLOPODIA VARIOLARIS,	*Coquand.* Synop. des Foss. Crétacés, Bulletin Soc. Géol. de France, 2e sér., t. xvi, p. 992, 1859.
— SUBNUDUM,	*Coquand.* Ibid.
PSEUDODIADEMA STRIATULUM,	*Cotteau* et *Triger.* Échin. du départ. de la Sarthe, p. 144, pl. xxxvii, figs. 13—15, 1859.
PSEUDODIADEMA ROISSYI,	*Cotteau* et *Triger.* Ibid.
DIPLOPODIA VARIOLARIS,	*Coquand.* Cat. rais des Foss. départ. Charente, p. 155, 1861.

DIPLOPODIA SUBNUDUM, *Coquand.* Ibid.
— VARIOLARIS, *Dujardin* et *Hupé.* Hist. Nat. des Zooph. Échinodermes, p. 501, 1862.
— SUBNUDA, *Dujardin* et *Hupé.* Ibid.
— STRIATULUM, *Dujardin* et *Hupé.* Ibid.
PSEUDODIADEMA VARIOLARE, *Cotteau.* Paléontologie Française, Terrain Crétacé, t. vii, p. 488, pls. 1117, 1118, 1119, and 1120, figs. 1—3, 1864.

Test large, subcircular, slightly subpentagonal, nearly equally depressed on the upper and under surfaces. Ambulacral areas narrow and contracted at the upper part by the poriferous zones; two rows of tubercles, 15—17 in each series, separated by a single line of granules; pores round, in oblique single pairs in the middle, widely bigeminal on the upper surface, and trigeminal near the peristome. Inter-ambulacral areas wide, with four rows of primary tubercles and two short rows of small secondary tubercles. The middle of the upper surface of the area nude and often depressed. Under surface convex, mouth-opening small; peristome with feeble entailles. Discal opening large, sharply angular, pentagonal.

Dimensions.—A.—Height half an inch; transverse diameter one inch. B.—Height half an inch; transverse diameter one inch and a half.

Description.—The identity of this species has long been uncertain from the impossibility of ascertaining the Urchin intended by the figure and description given by Brongniart, without reference to the type specimen; this comparison has now fortunately been made by M. Cotteau, who has given admirable figures and most ample descriptions of the various forms *P. variolare* exhibits under different conditions of age and habitat. I shall first describe the general characters of the species, and secondly point out the three chief varieties it assumes.

The test is of medium size, subcircular, sometimes lightly pentagonal, and equally depressed at both poles. The ambulacral areas are narrow, and contracted at their upper part by the excessive development of the poriferous zones in this region; they possess two rows of large tubercles, 15—17 in each series, according to size and age, which gradually diminish in size from the equator to the peristome, and become small and rudimentary on the upper surface (Pl. XVII, fig. 3 *a*). The rows are closely approximated, there being only a single series of small granules, of unequal size, forming a zigzag line, between them; the tubercles have narrow areolas, prominent bosses, with sharply crenulated summits, and deeply perforated mammillons (fig. 4). The poriferous zones are narrow, the pores round, in single oblique pairs on the sides, in triple oblique pairs near the peristome, and they are widely bigeminal in all the upper fourth of the zones (fig. 5 *a*).

The interambulacral areas are nearly four times as wide as the ambulacral in the specimen figured in Pl. XVII, figs. 3 *a*, *b*, *c*, rather more than one inch in diameter. There are four rows of large tubercles, and two secondary rows, at the ambitus; the two inner primary rows, with fourteen tubercles in each series, extend from the peristome to the apical

disc, and the outer primary rows are absent from the three uppermost plates (fig. 3 *a*). In a large specimen from the Chalk-Marl of Dorset, B, one and a half inches in diameter, the ambital plates have six and eight rows of large tubercles, and two rows of small secondary tubercles. There are sixteen tubercles in each inner series which alone reach the disc, the second, third, and fourth rows disappear as the plates shorten on the upper surface. The small secondary tubercles, situated near the poriferous zones, form a short series between the peristome and equator; they are scarcely larger than granules, but are, nevertheless, mammillated and perforated, and their presence, position, and development, constitute one of the specific characters of this Urchin. The interambulacral tubercles are nearly identical in size with those of the ambulacral areas (fig. 4). They have narrow areolas, prominent bosses, with sharply crenulated summits, and large perforated mamillons. The miliary zone is narrow at the sides and infra-margin, with two rows of granules of unequal sizes; at the upper surface it becomes nude and depressed (fig. 3 *a*) around the discal opening, a character which appears in excess in the var. *subnudum*. A number of granules, of different sizes, form hexagonal circlets around the areolas (fig. 5 *a*).

The under surface is convex, and the small mouth-opening occupies a slight depression; the peristome is circular, and its margin notched with feeble entailles (fig. 3 *b*). The opening for the apical disc was very large (fig. 3 *a*), widely pentagonal, and sharply angular, extending into the nude portion of the inter-ambulacra. None of the specimens as yet found contain any of the discal plates. (See likewise Pl. XVIII, figs. 1 *a*, *b*, and fig. 2).

Authors have recognised three distinct forms of this species, which some have described as so many separate species, whilst others regard them as varieties of one.

1st. Var. *a*, *variolare*, identical with Brongniart's type form, is found in the Upper Greensand of Wiltshire and the "Chloritic Marl" of Chard (Pl. XVIII, fig. 2) and l'Étage Cénomanien of Villers-sur-Mer, Calvados, France, from which localities I have specimens. Its upper surface is more or less depressed, and its outline is circular or subpentagonal. The inter-ambulacra have four rows of primary and two rows of small secondary tubercles; the under surface is convex, and the mouth-opening small.

2nd. The var. *b*, *subnudum*, has the upper surface remarkably nude, from the absence of granules in the upper part of the miliary zone; the test is higher, and my specimen from the "Chloritic Marl" of Chard has a thicker structure than var. *a*.

3rd. The var. *c*, *Roissyi*, is still higher and much larger than var. *b*; it has a more tuberculous appearance, and from six to eight rows of tubercles in the inter-ambulacra. I have two specimens before me that agree very well with M. Desor's diagnosis of this form, which he considers a good species, or at all events a large variety of *P. subnudum*. After a critical study of all these forms, I can find no good structural character for separating them, and therefore consider them as varieties of *P. variolare*, depending on age or habitat for the differences they exhibit in the size, thickness, and number of tubercles in the inter-ambulacral areas.

Affinities and Differences.—*Pseudodiadema variolare* is one of the most perfect types of a

tetragrammous Diadema with bigeminal pores. It very much resembles *P. Brongniarti,* Agas., from the Grey Chalk, but is distinguished from the latter by having its upper and under surfaces more depressed, the ambulacral areas narrower, their rows of tubercles shorter, and those on the upper surface more rudimentary; the poriferous zones are much wider on the upper fourth, and have the pores more largely bigeminal; the base likewise is more convex, wider, and less contracted than in *P. Brongniarti.*

Locality and Stratigraphical Position.—P. variolare is found in the Upper Greensand of Warminster, and the "Chloritic Marl" near Chard; from the latter locality I have specimens that represent the var. *b., subnudum,* and var. *c., Roissyi.* The large specimen was kindly communicated by the Rev. C. W. Bingham, of Binghams Melcombe, near Dorchester; it was collected from the Upper Greensand of that neighbourhood—the precise locality is not recorded.

Foreign Localities.—M. Cotteau has given a wide range to the distribution of this species in France, and records—"Villers-sur-Mer, Cauville, Vaches-Noires, Dives, Saint-Jouin (Calvados); Octeville (Manche); Fécamp, Le Havre, Rouen (Seine-Inférieure); Vimoutiers, Gracé, La Perrière (Orne); Prèsagny près Vernon (Eure); Berneuil (Oise); Grandpré (Ardennes); La Fauche près le Villard-de-Lans (Isère); Le Mans, La Raglasse, Yvré-l'Évêque (Sarthe); Corzé (Maine et Loire); Touvois (Loire-Inférieure); Angoulême (Charente); île Madame, Saintes (Charente-Inférieure). Assez abondant. Étage Cénomanien, commun surtout dans la zone à *Scaphites æqualis.*—Lillebonne (Seine-Inférieure). Rare. Étage turonien."

In the Hils conglomerate, near Essen, Hanover. Desor.

History.—Figured for the first time by Brongniart in 1822, as *Cidarites variolaris,* in his 'Géognosie Physique des Environs de Paris,' from a specimen collected at Havre in the Upper Greensand.

In the 'Catalogue raisonné des Échinides,' 1846, MM. Agassiz and Desor separated certain varieties of this species from the type which they found in the museums of France, under the names *Diadema subnudum* and *D. Roissyi;* those, however, I have endeavoured to demonstrate are merely varieties of *P. variolare.*

Pseudodiadema Brongniarti, *Agassiz*, 1840. Pl. XX, fig. 2 *a—c*; XXI a, figs. 2 *a—f*, 3, 4; XXI b, figs. 1—3 *a—e*.

Tetragramma Brongniarti, *Agassiz*. Desc. des Échinides fossiles de la Suisse, t. ii, p. 25, pl. xiv, figs. 4—6, 1840.
— — *Agassiz* et *Desor*. Catal. rais. des Échinides, Ann. Sc. Nat., 3e sér., t. vi, p. 350, 1846.
— — *Bronn*. Index Palæontologicus, p. 1261, 1849.
Diadema — *D'Orbigny*. Prodrome, t. ii, p. 142, Ét. 19, No. 328, 1850.
— — *Renevier*. Mém. Géol. sur la Perte du Rhône, p. 32, 1853.
— — *Forbes*. In Morris's Catalogue of British Fossils, 2nd ed., p. 76, 1854.
Pseudodiadema — *Desor*. Synopsis des Échinides fossiles, p. 74, 1856.
Diadema — *Woodward*. Mem. of the Geol. Surv., Decade V, 1856.
— — *Pictet*. Traité de Paléontol., 2e éd., t. iv, p. 244, 1857.
Pseudodiadema — *Dujardin* et *Hupé*. Hist. Nat. des Zoophytes, Echinodermes, p. 498, 1862.
— — *Cotteau*. Paléontologie Française, Terrain Crétacé, t. vii, p. 456., pl. 1109, 1865.

Test large, subcircular, elevated; sides tumid, depressed at the upper surface, narrow, rounded, and contracted on the under surface; ambulacral areas narrow, with two rows of tubercles, separated by a double series of small granules of unequal sizes; poriferous zones narrow, straight; pores round, in single pairs from the peristome to the ambitus, and bigeminal thence to the disc-opening; inter-ambulacral areas wide, with four rows of primary tubercles, nearly identical in size with those of the ambulacra, and two short rows of very small secondaries near the zones. Mouth-opening small, in a considerable depression; peristome narrow, with feeble and nearly equal-sized entailles.

Dimensions.—a.—Height six tenths of an inch; transverse diameter one inch and a half. b.—Transverse diameter two inches and a half.

Description.—The test of this species exhibits so close a resemblance in many of its anatomical details to that of *Pseudodiadema variolare*, that, were it not for some differences in the size, shape, and development of the shell, and in the structure of the ambulacra, I should hesitate to separate it from that form; after all, these differences may not be specific, but may have arisen from habitat and other physical conditions. A test of each species, with spines attached, for the purpose of comparison, is still with me a desideratum; however, as this Urchin is considered by most authors to be distinct from *P. variolare,* I shall describe the fossils I have figured under the name *P. Brongniarti*, Agas. These

specimens have been compared with typical examples from the Upper Greensand of the Perte du Rhône, and identified as the true forms of *P. Brongniarti*, Agas.

The test is moderately large, sub-circular, and elevated; the sides are tumid, and the upper surface is flat; the base is convex, contracted at the circumference, and having the peristome sunk in a considerable depression (Pl. XXI A, fig. 2 *c*). The ambulacral areas are narrow, and sharply lanceolate; they have two rows of primary tubercles, from sixteen to seventeen in each row, which diminish gradually from the ambitus to the peristome and the disc; they are placed closely together, and have narrow ring-like areolas; the bosses are stout, with sharply crenulated summits, and the mammillons are large and perforated (fig. 2 *e*); a row of granules, of unequal sizes, sometimes mammillated, separates the tubercles at the middle and base of the area, whilst in the upper part branches of fine granules pass off horizontally, forming circlets around the tubercles (fig. 2 *e*). The poriferous zones are narrow; the pores are in single pairs in the middle and infra-marginal region, near the peristome they lie in triple oblique pairs, above the ambitus they fall out of their regular ranks, and at the upper surface are distinctly bigeminal (Pl. XXI A, fig. 2 *b*).

The inter-ambulacral areas are more than twice the width of the ambulacral; they have four rows of primary tubercles nearly identical with those in the ambulacra. The two inner rows are best developed, and extend from the peristome to the disc, whilst the external rows are absent from the three uppermost plates; in the large specimen there must have been sixteen to eighteen tubercles in each internal row (Pl. XX, figs. 2 *a* and *b*); a series of small unequal secondary tubercles ascends from the peristome to above the ambitus, situated between the primary tubercles and the zones (Pl. XXI A, figs. 2 *d*, *e*); they are altogether absent from the upper surface, but constant in the region I have described. The miliary zone is narrow in the infra-marginal region, wider in the middle, and expands at the upper surface; it is filled with four rows of small irregular granules, among which a number of small mammillated tubercles as large as the secondaries are placed (Pl. XXI A, fig. 2 *e*); above the ambitus horizontal branches of granules extend from the median rows, separating the areolas, and forming hexagonal divisions between them (fig. 2 *e*); at the upper fourth of the area the granules disappear from the middle of the zone, and a triangular nude space is exposed, having its base at the disc and its apex at the fifth plate; the circlets of granules are absent from the areolas of these plates.

The upper surface is flat, and the opening for the apical disc large and pentagonal, the angles extending into the inter-ambulacra (fig. 2 *b*.)

The base is convex and contracted at the side; the centre is concave, about one third the width of the shell, and the mouth-opening lies in a considerable depression; the peristome is small, about one third the width of the shell; in a fine test showing the base one and a half inch in diameter; that of the peristome is half an inch (fig. 2 *c*).

Affinities and Differences.—P. Brongniarti is distinguished from its congeners by its elevated test, with tumid sides, flat upper surface, and contracted, convex under surface.

PLATE IX.

CIDARIS HIRUDO, *Sorignet,* 1850.

From the White Chalk.

Fig. 1 *a*. Test and spines natural size in the Collection of Henry Willett, Esq., F.G.S. (P. 64.)

1 *b*. Lateral view of the same test, natural size.

1 *c*. Small spine from the ambulacral tubercles, magnified three diameters.

Fig. 2 *a*. Upper surface of a test, natural size, belonging to the British Museum.

2 *b*. Interambulacral plate, ambulacral area and poriferous zones of the same, magnified three diameters.

2 *c*. Apical disc and anal plates of the same, natural size.

2 *d*. One ovarial and two ocular plates of the same, magnified twice.

Fig. 3. Under surface of another test, natural size, belonging to the British Museum.

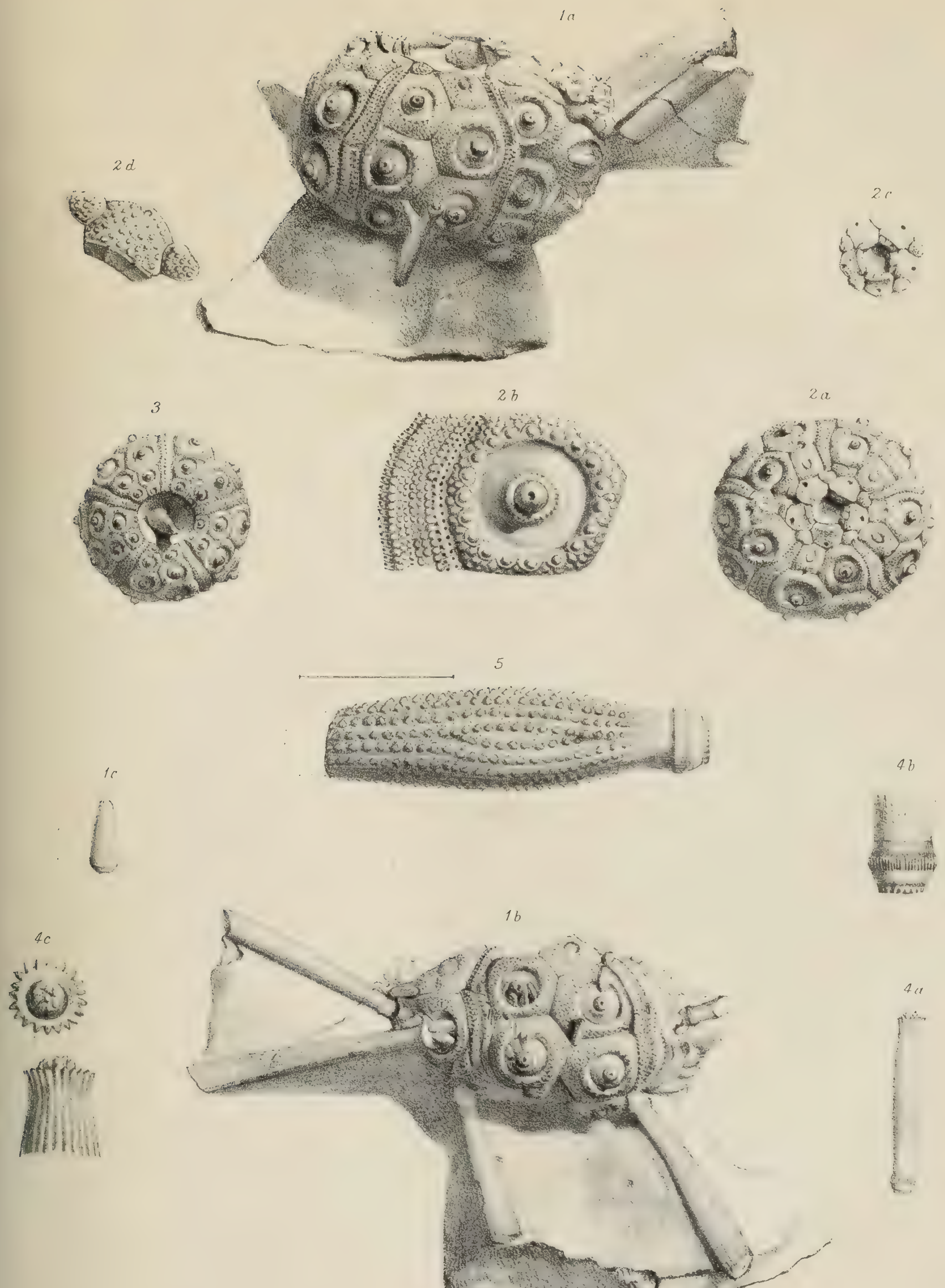
Fig. 4 *a*. Primary spine, natural size, belonging to the British Museum.

4 *b*. Lower portion of the same, magnified three diameters.

4 *c*. Upper portion showing its stellate termination, magnified three diameters.

Fig. 5. Primary spine, magnified three times, in the collection of Rev. T. Wiltshire, F.G.S.

Pl. IX



C.R. Bone, del et lith

Printed by W West

PLATE X.

CIDARIS HIRUDO, *Sorignet*, 1850.

From the White Chalk.

Fig. 1 *a*. Test the natural size, with spines attached, in the collection of Professor Tennant, F.G.S. (P. 64.)

1 *b*. Primary spine of the same, magnified twice.

Fig. 2. Lateral view of another specimen belonging to the British Museum.

Fig. 3 *a*. Upper surface of a small specimen belonging to the British Museum.

3 *b*. Under surface of a small specimen belonging to the British Museum.

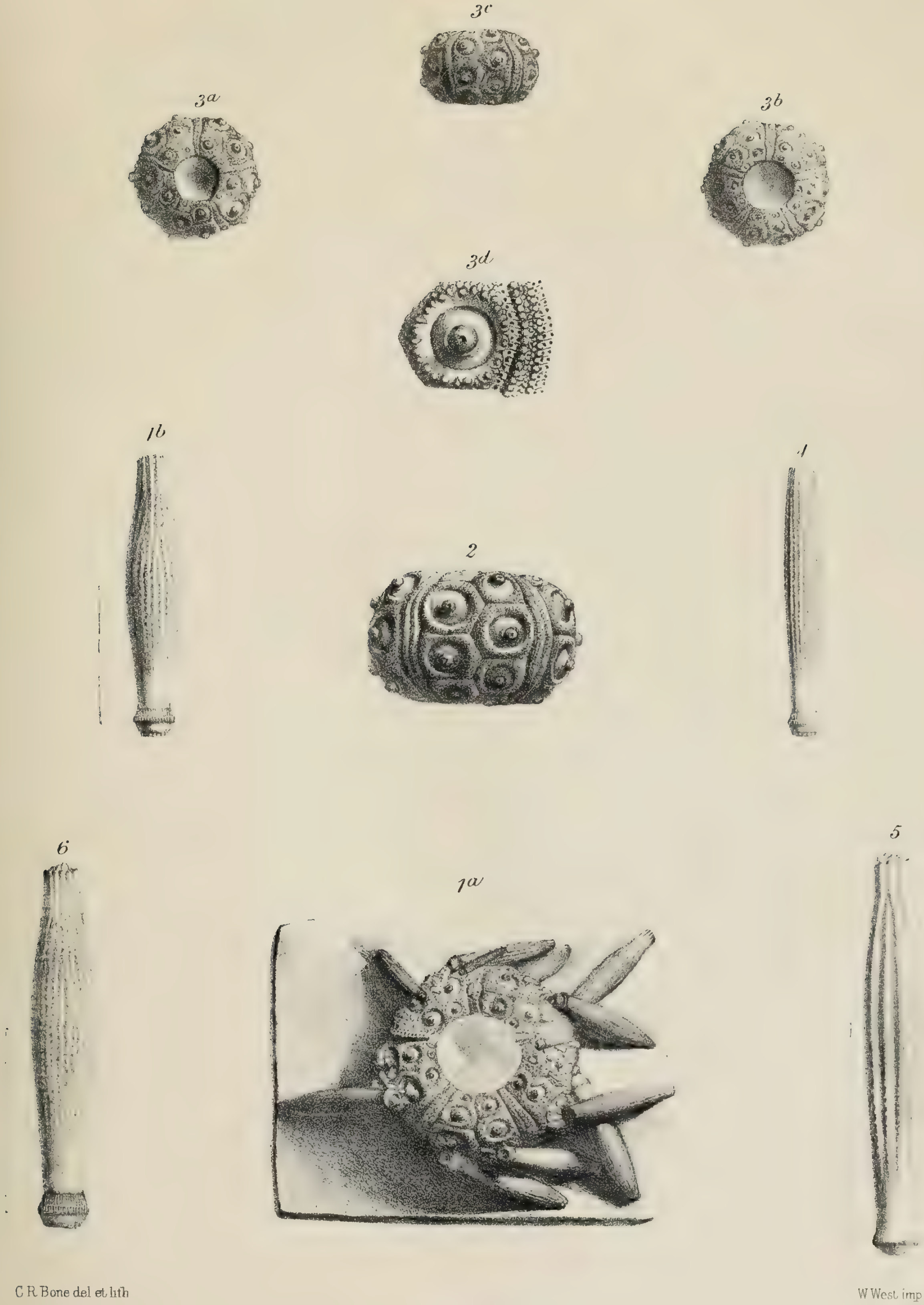
3 *c*. Lateral view of a small specimen belonging to the British Museum.

3 *d*. Interambulacral plate, ambulacral area zones of the same, magnified three times.

Fig. 4. Primary spine magnified twice, in the cabinet of the Rev. T. Wiltshire, F.G.S.

Fig. 5. Primary spine magnified twice, in the cabinet of the Rev. T. Wiltshire, F.G.S.

Fig. 6. Primary spine magnified twice, in the cabinet of the Rev. T. Wiltshire, F.G.S.



C R Bone del et lith

W West imp

PLATE XII.

From the White Chalk.

Fig. 1 *a*. Test and spines of *Cidaris intermedia,* Wiltsh., natural size. Collection of Rev. Thomas Wiltshire, F.G.S. (P. 69).

b. Spine belonging to the tubercle, the third from the peristome, magnified.

Fig. 2. Spine of *Cidaris hirudo* (?), magnified.

Fig. 4. Unusual form of spine, probably belonging to *C. sceptrifera,* magnified. Collection of Rev. Thomas Wiltshire, F.G.S.

From the Lower Chalk.

Fig. 3 *a*. Spine of *Cidaris dissimilis,* Forb., natural size. Collection of Rev. Thomas Wiltshire, F.G.S. (P. 46)

b. Head and spine of same magnified.

Fig. 5. Spine of *Cidaris pleracantha,* Agass., natural size. Collection of J. R. Capron, Esq., F.G.S. (P. 67.)

From the Upper Greeensand.

Fig. 6. Spine of *C. Dixoni*, natural size. Collection of Rev. Thomas Wiltshire, F.G.S. (P. 67.)

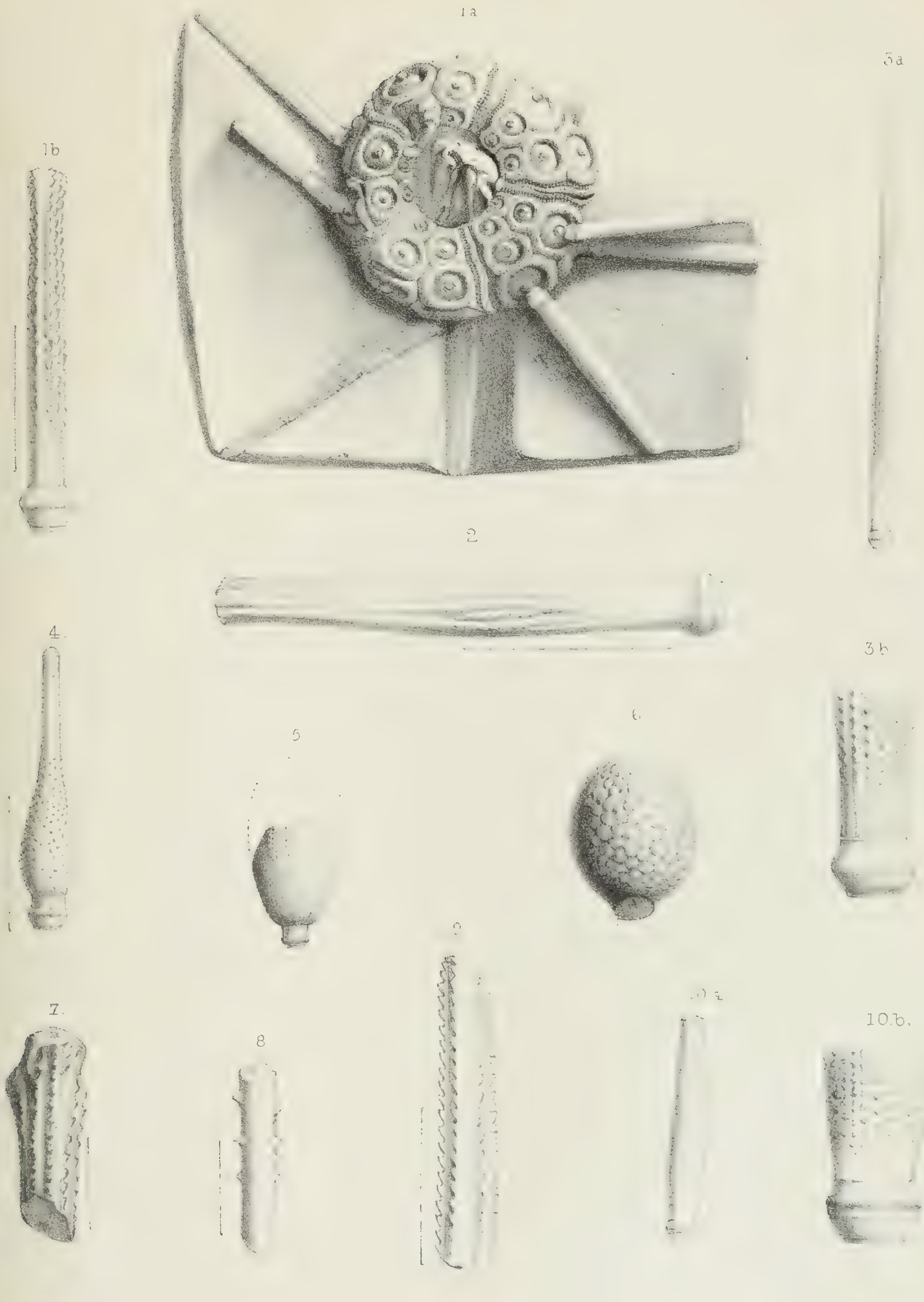
From the Red Chalk.

Figs. 7, 8, 9. Spines of *Cidaris,* natural size, from Hunstanton. Cabinet of Rev. Thomas Wiltshire, F.G.S. (P. 79.)

Fig. 10 *a*. Spines of *Cidaris,* natural size, from Speeton. (P. 79.)

Fig. *b*. The same, magnified.

Pl. XII.



C. R. Bone del et lith.

M. & N. Hanhart imp.

PLATE XIII.

From the White Chalk.

CIDARIS CLAVIGERA, *König*, 1822.

Fig. 1 *a*. Test and spines, natural size. (P. 71.)
b. Spine of same, magnified.
Fig. 2. Spine of same, natural size.
Fig. 3 *a*. Test and spines, natural size. (P. 71.)
b. Spine of same, natural size.
c. Spine of same, magnified.
Fig. 4 *a*. Test and spines, natural size. (P. 71.)
b. Spine of same, magnified.
Fig. 5 *a*. Spine of *C. clavigera*, of elongate form, natural size. (P. 71.)
b. The same, magnified.

From the Lower Chalk.

Fig. 6 *a*. Plates of *Cidaris dissimiles*, Forb. (P. 46.)
b. One of the plates, magnified. All the above are from the Cabinet of the Rev. Thomas Wiltshire, F.G.S.
Fig. 7 *a*. Spine of *Cidaris pleracantha?* natural size. Collection of J. R. Capron, Esq., F.G.S.
b. The same, magnified. (P. 67.)
Figs. 8, 9, 10. Spines of *Cidaris Bowerbankii*, Forb. Collection of Rev. T. Wiltshire, F.G.S. (P. 77.)
Fig. 11. Do. do. Do. J. R. Capron, Esq., F.G.S.
Fig. 13 *a*. Do. natural size. Cabinet of Rev. Thomas Wiltshire, F.G.S.
b. Head and neck of same, magnified.
Fig. 14. Spine of same, natural size. Cabinet of Rev. Thomas Wiltshire, F.G.S.

XIII

C.R. Bone del et lith

PLATE XIV.

From the Chloritic Marl.

Fig. 1 *a*. Pedinopsis Wiestii, *Wright*, upper surface of the test, natural size. In the collection of Mr. Wiest.

1 *b*. ,, ,, under surface, natural size.

1 *c*. ,, ,, lateral view, natural size.

1 *d*. Ambulacral area, poriferous zones, and interambulacra, magnified four diameters.

1 *e*. Base of an ambulacral area, showing the disposition of the pores, × four times.

Fig. 2 *a*. Fistulous spine of a Diadema from the White Chalk, × six times. British Museum.

2 *b*. Do. do. do. × six times.

2 *c*. Do. do. do. × six times.

2 *d, e*. Do. do. do. × six times.

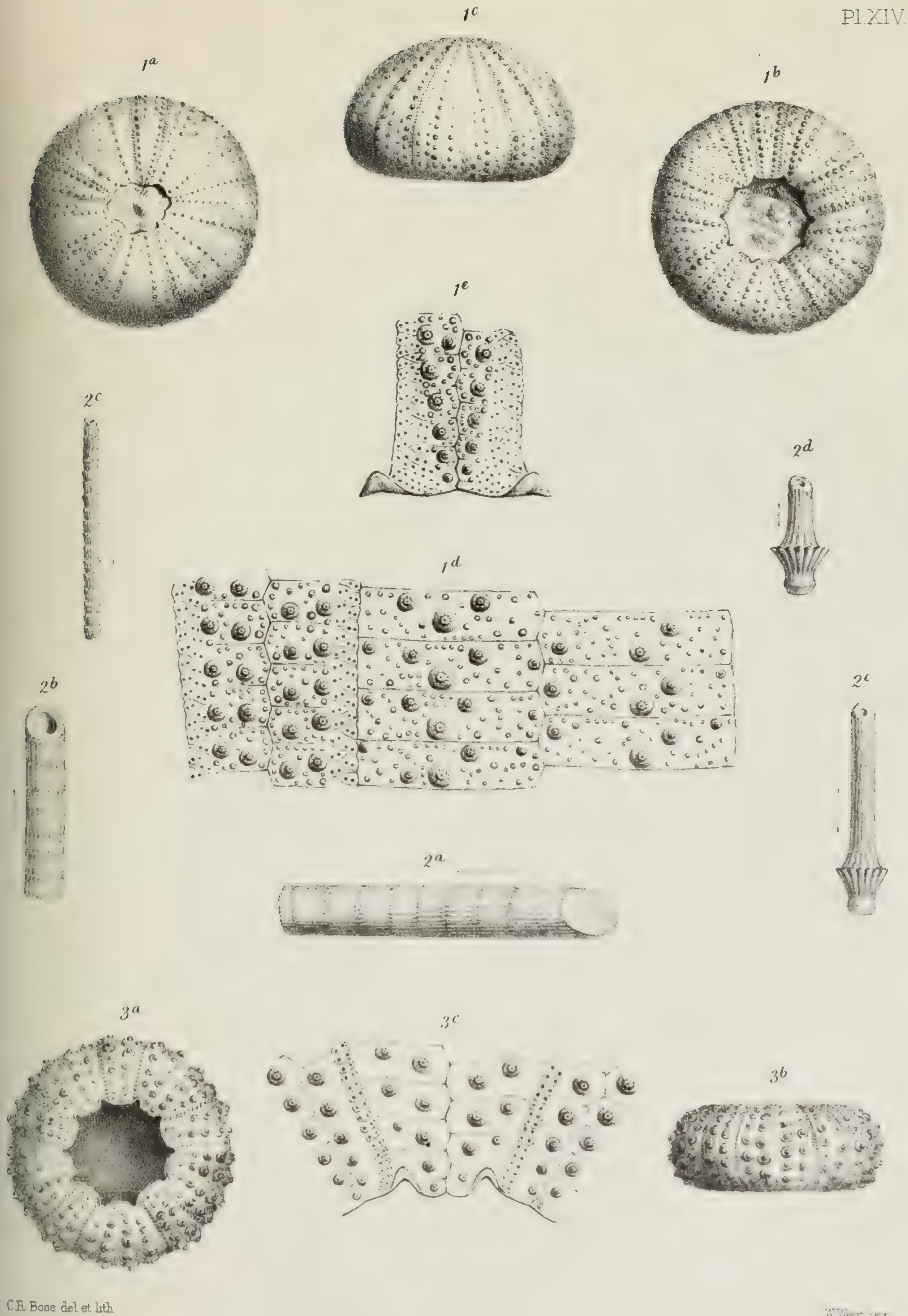
From the Lower Greensand.

Fig. 3 *a*. Pseudodiadema rotulare, *Agassiz*, base magnified one half. In the Cabinet of Dr. Wright, F.R.S.E. (P. 87.)

3 *b*. ,, ,, lateral view do. do.

3 *c*. ,, ,, segment of the base, do. four times.

Pl. XIV.



C.R. Bone del et lith

PLATE XV.

From the Lower Greensand.

Fig. 1 *a.* PSEUDODIADEMA FITTONII, *Wright,* test natural size, cabinet of Dr. Wright, F.R.S.E. (P. 90.)

1 *b.* Upper surface magnified one half.

1 *c.* Under surface do. do.

1 *d.* Lateral view do. do.

1 *e.* Ambulacra, poriferous zones, and interambulacra, magnified four times.

1 *f.* Portion of an ambulacra, magnified four times.

1 *g.* One tubercle and pores, magnified six times.

From the Upper Greensand.

Fig. 2 *a.* PSEUDODIADEMA BENETTIÆ, *Forbes*, magnified one half, British Museum, and cabinet of Dr. Wright, F.R.S.E. (P. 101.)

2 *b.* Upper surface of the same test do. do.

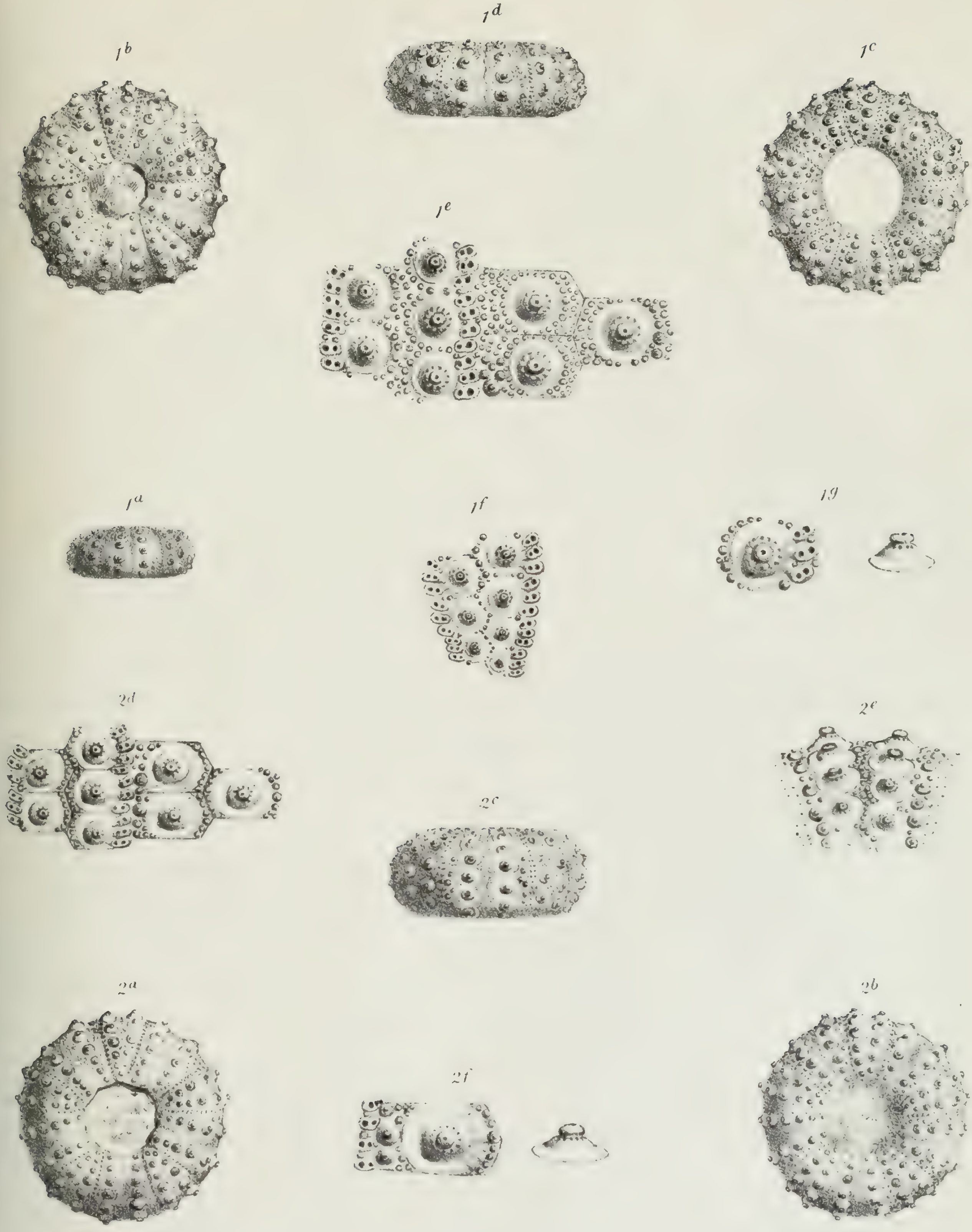
2 *c.* Lateral view of do. do. do.

2 *d.* Ambulacra, zones, and interambulacra, magnified four times.

2 *e.* Ambulacra seen in profile do. do.

2 *f.* Inter-ambulacral plate and tubercle, magnified six times.

Pl. XV



C R. Bone del. et lith

W. West imp

PLATE XVI.

From the Gault.

Fig. 1 *a*. Pseudodiadema Wiltshirii, *Wright*, natural size, belonging to the Rev. T. Wiltshire, F.G.S. (P. 94.)

1 *b*. Lateral view of the same test, magnified one half.

1 *c*. Ambulacra, zones, and interambulacra, magnified four times.

1 *d*, *e*. Primary tubercle, magnified six times.

1 *f*. Portion of a spine, magnified six times.

Fig. 2. Spine magnified.

Fig. 3. Do., natural size.

From the Grey Chalk.

Fig. 4 *a*. Pseudodiadema ornatum, *Goldfuss*, sp., upper surface, magnified one half, belonging to the British Museum. (P. 103.)

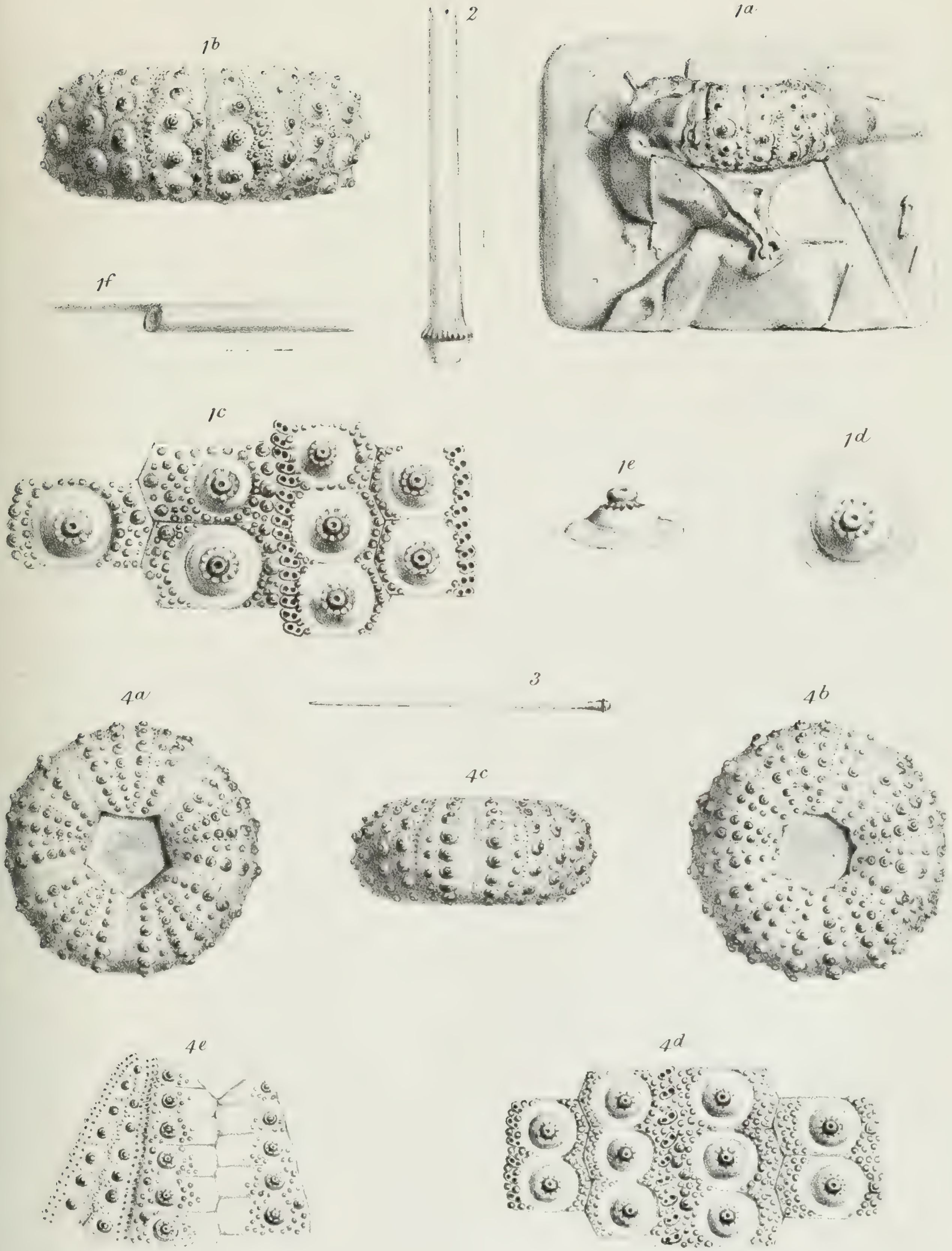
4 *b*. Under surface of the same, magnified one half.

4 *c*. Lateral view of the same, do. do.

4 *d*. Ambulacral area, interambulacral area, and pores, magnified four times.

4 *e*. Miliary zone and upper portion of an ambulacrum, do. do.

Pl. XVI



C.R. Bone del. et lith.

W. West imp.

PLATE XVII.

From the Chalk Marl.

PSEUDODIADEMA VARIOLARE, *Brongniart*, sp.

Fig. 1 *a*. Test, the natural size, with spines. British Museum. (P. 107.)

1 *b*. Spine, greatly magnified.

Fig. 2. Test, magnified one half. In the cabinet of Dr. Wright, F.R.S.E.

Fig. 3 *a*. Lateral view, magnified one half. Do.

3 *b*. Base view, do. Do.

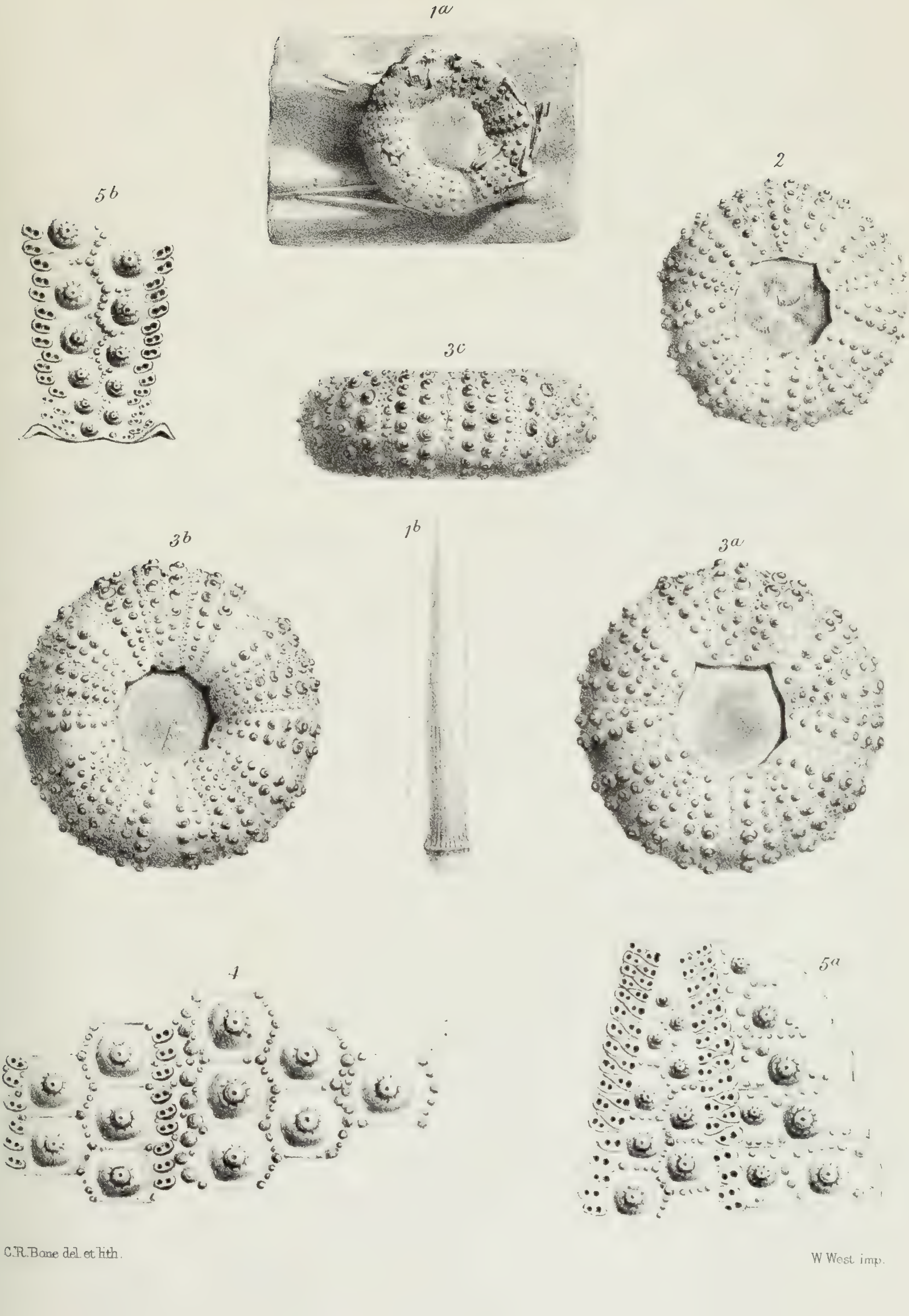
3 *c*. Upper surface, do. Do.

Fig. 4. Ambulacral area, and zones and inter-ambulacral plates, magnified six times. Dr. Wright's cabinet.

Fig. 5 *a*. Upper portion of the ambulacra and poriferous zone, showing the bigeminal pores, magnified six times.

5 *b*. Infra-marginal portion of the ambulacral area, showing the triple oblique pairs of holes at the base of the area, magnified six times.

Pl XVII.



C.R. Bone del. et lith.

W West imp.

PLATE XVIII.

From the Grey Chalk.

Fig. 1 *a*. Pseudodiadema variolare, *Brongniart*. Upper surface of a large test, in the cabinet of the Rev. T. Wiltshire, F.G.S. Restored, natural size. (P. 107.)

1 *b*. Under surface of the same, do. Do.

1 *c*. Ambulacral plate, magnified six diameters.

From the Chloritic Marl.

Fig. 2. Pseudodiadema variolare, *Brongniart*. A very perfect specimen from Chard, in the cabinet of Dr. Wright, F.R.S.E. Magnified one half diameter.

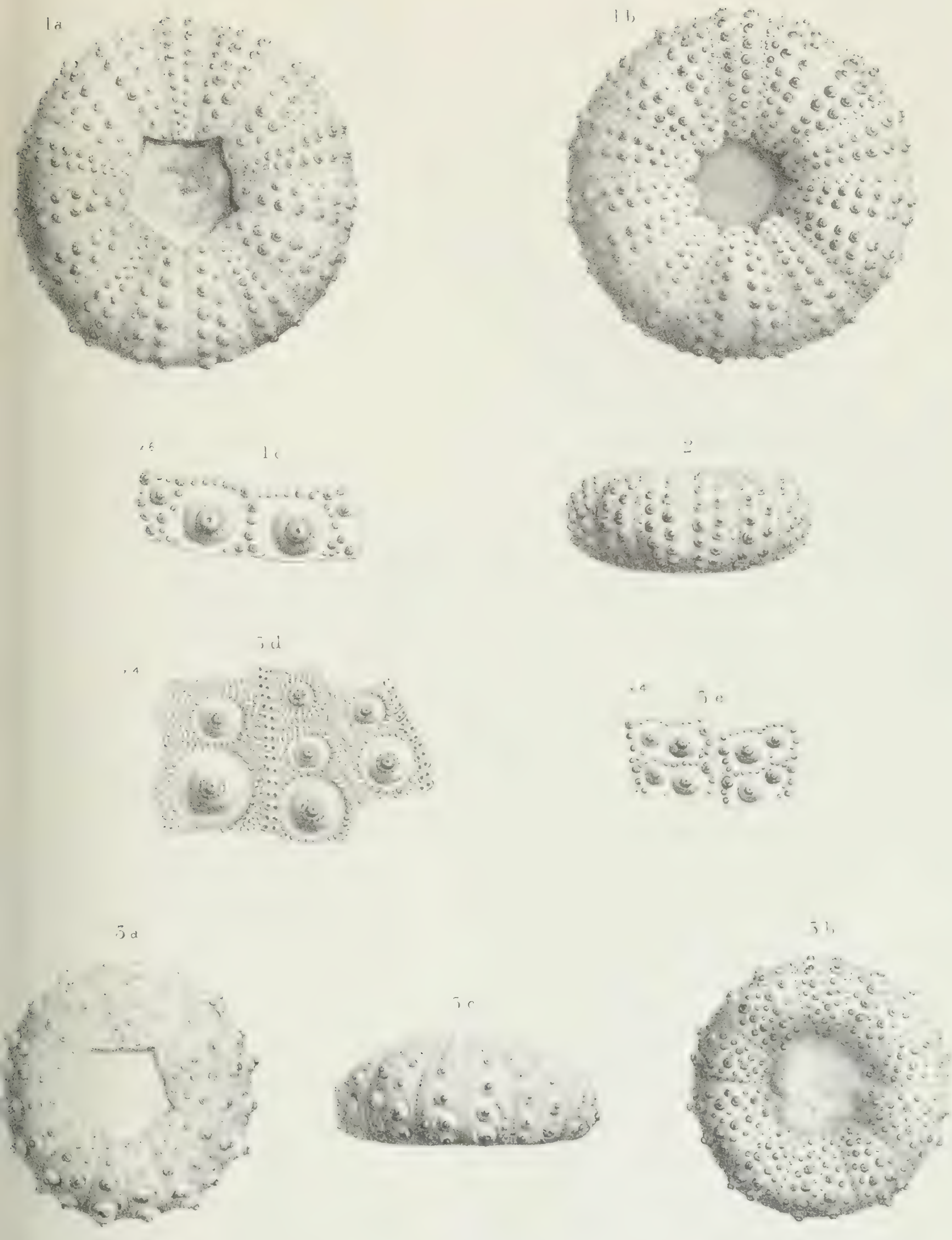
Fig. 3 *a*. Pseudodiadema Rhodani, *Agassiz*. Upper surface, magnified one half. In the cabinet of Dr. Wright, F.R.S.E. (P. 96.)

3 *b*. Under surface of the same. Do. Do.

3 *c*. Lateral view of do. Do. Do.

3 *d*. Ambulacra, inter-ambulacra, and pores, magnified four times.

3 *e*. Four inter-ambulacral plates, magnified four times.



...e del et lith

PLATE XIX.

From the Grey Chalk.

Fig. 1 *a.* Pseudodiadema ornatum, *Goldfuss.* Test, natural size, in the cabinet of Dr. Wright, F.R.S.E. (P. 103.)

1 *b.* Same test restored and magnified half a diameter, showing the base.

1 *c.* Lateral view of do. do., do.

1 *d.* Portion of the ambulacra, inter-ambulacra, and zones, magnified four times.

1 *e.* Inter-ambulacra, plate, and tubercle, magnified six times.

From the Upper Greensand.

Fig. 2 *a.* Pseudodiadema Michelini, *Agassiz.* Upper surface, magnified one half. In the cabinet of Dr. Wright, F.R.S.E. (P. 99.)

2 *b.* Under surface of the same test, do. Do.

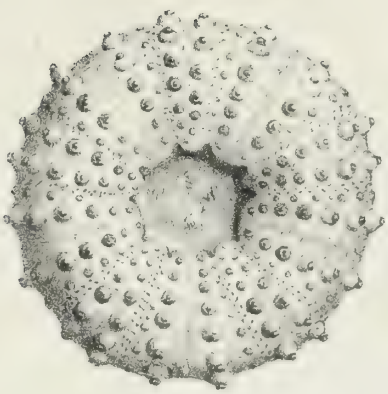
2 *c.* Lateral view of do., do. Do.

2 *d.* Portion of ambulacra, inter-ambulacra, and pores, magnified four times.

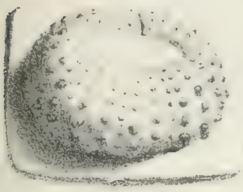
2 *e.* Do. magnified four times.

2 *f.* Base of the ambulacra, do.

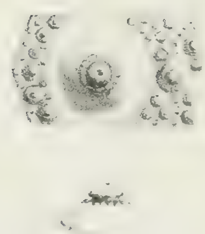
1 b ×2



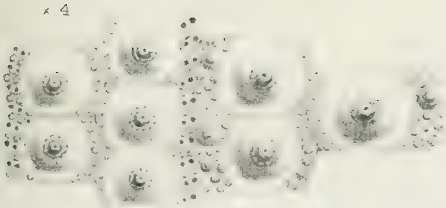
1 a



1 e ×6

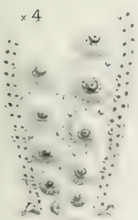


1 d ×4

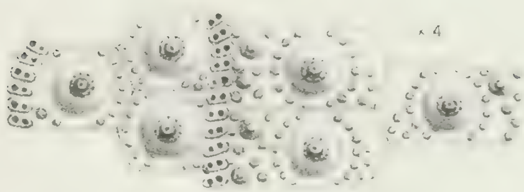


1 c

2 f ×4

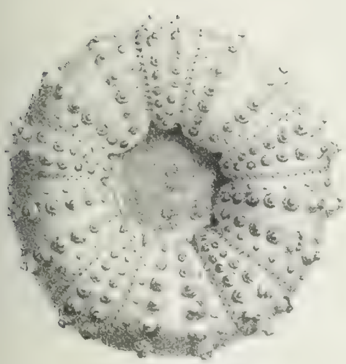


2 d ×4



2 e ×4

2 b



2 c

2 a

R. Bone del et lith

M & N Hanhart Imp

PLATE XX.

From the Lower Greensand.

Fig. 1 *a*. Pseudodiadema Malbosi, *Agassiz*. Upper surface of the test, natural size. From the Collection of the Rev. T. Wiltshire, F.G.S. (P. 91.)

1 *b*. Upper surface of the same specimen.

1 *c*. Lateral view of do.

1 *d*. Inter-ambulacral plates, ambulacral area, and poriferous zones, magnified four times.

1 *e*. Basal portion of an ambulacral area, magnified four times.

1 *f*. Portion of a primary spine, magnified five times.

From the Grey Chalk.

Fig. 2 *a*. Pseudodiadema Brongniarti, *Agassiz*. Fragment of a large test, upper surface, natural size, in the cabinet of Rev. T. Wiltshire, F.G.S. (P. 111.)

2 *b*. Under surface of the same, do.

2 *c*. Base of the ambulacral area, magnified four times.

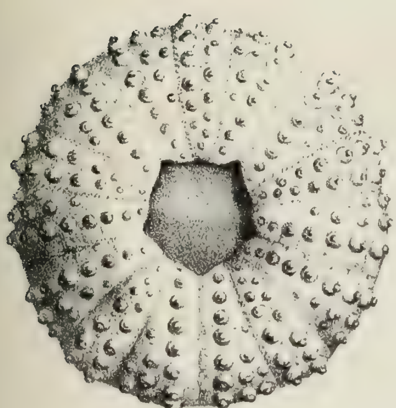
Pl XX

2a

2b

2c

1g

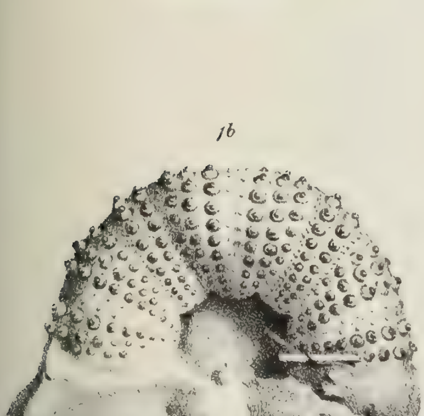


1c

1f

1d

1b



1e

1a

C.R. Bone del. et lith

W West imp

PLATE XXI.

From the Chloritic Marl.

Fig. 1 *a*. Pseudodiadema ornatum, *Goldfuss*. Upper surface, magnified one half, in the cabinet of Dr. Wright, F.R.S.E. (P. 103.)

1 *b*. Lateral view of the same test, magnified one half.

1 *c*. Portion of the ambulacra, inter-ambulacra and pores, magnified four times.

1 *d*. Do. do. and spine, magnified four times.

From the Grey Chalk.

Fig. 2 *a*. Another specimen, with spines, in the cabinet of the Rev. T. Wiltshire, F.G.S.

2 *b*. Portion of the ambulacra, inter-ambulacra and zones, magnified four times.

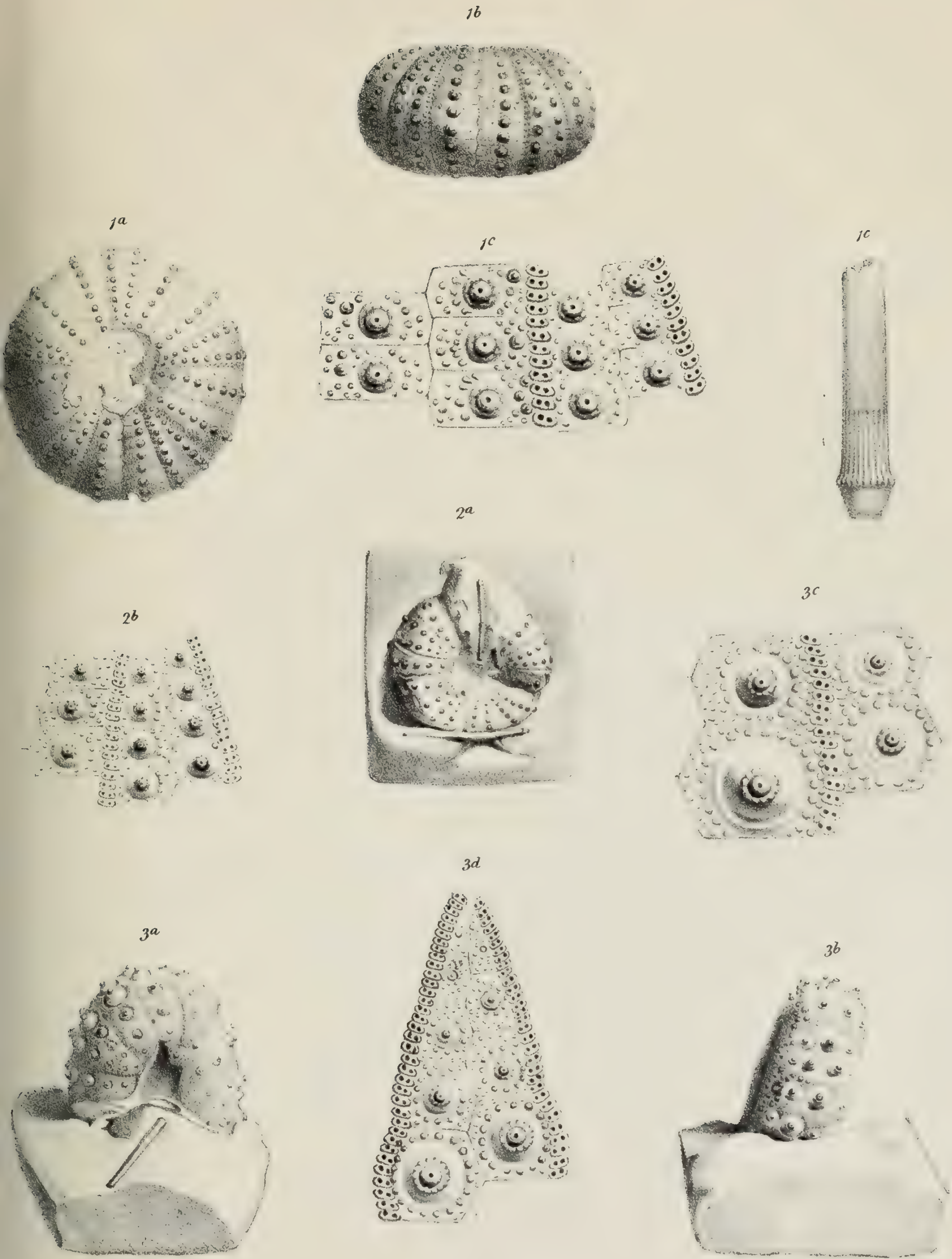
Fig. 3 *a*. Pseudodiadema Normaniæ, *Cotteau*. Upper surface of the test, natural size, in the cabinet of the Rev. T. Wiltshire, F.G.S. (P. 105.)

3 *b*. Lateral view of the same, natural size.

3 *c*. Ambulacral and inter-ambulacral plates, magnified four times.

3 *d*. Ambulacral area, magnified three times.

Pl.XXI



C.R. Bone del. et lith.

W. West imp.

PLATE XXI A.

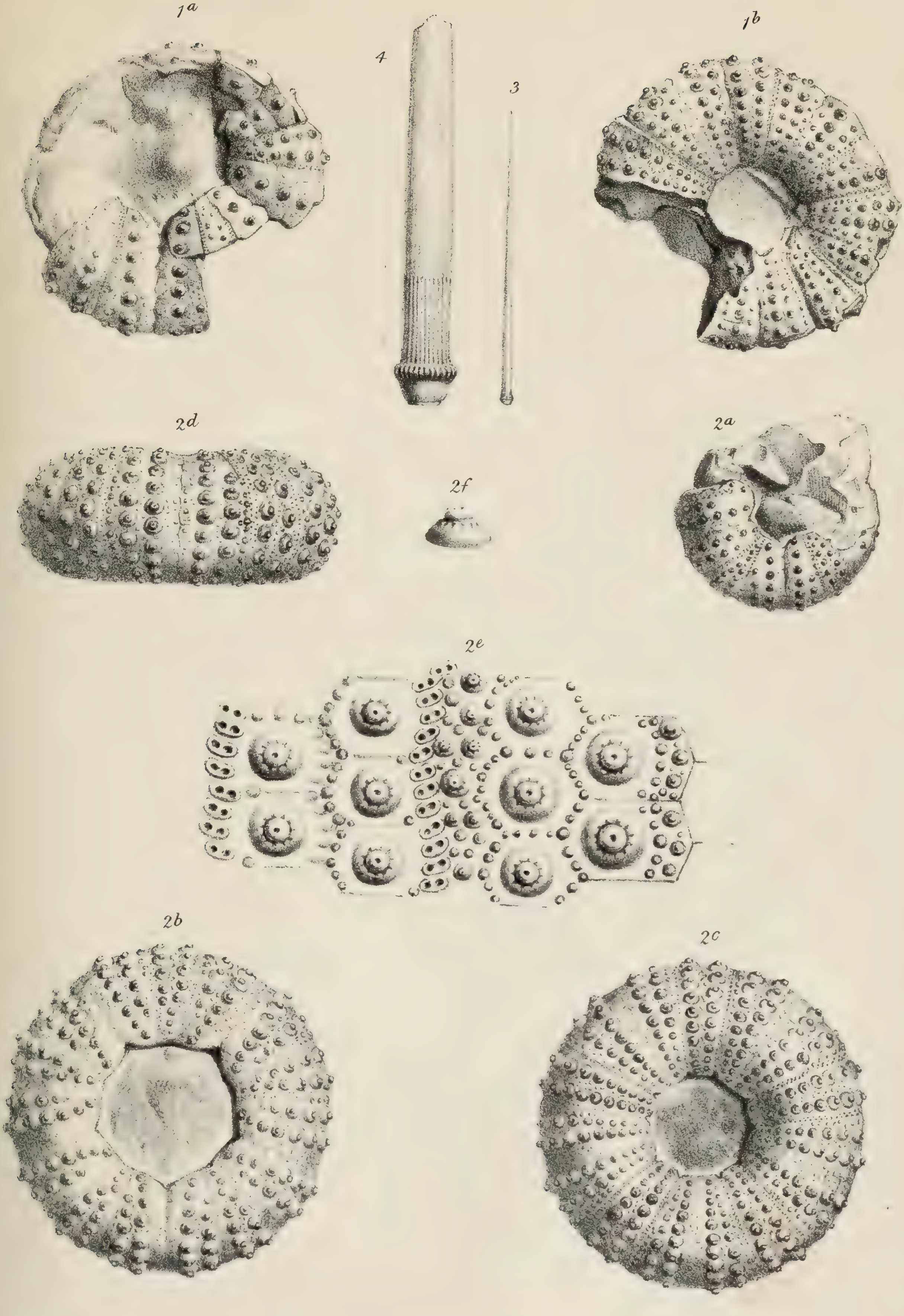
From the Grey Chalk.

Fig. 1 *a*. PSEUDODIADEMA ORNATUM, *Goldfuss*, from the cabinet of the Rev. T. Wiltshire, F.G.S. Upper surface, natural size. (P. 103.)

1 *b*. Under surface, natural size.

Fig. 2 *a*. PSEUDODIADEMA BRONGNIARTI, *Agassiz*. British Museum, natural size. (P. 111.)

2 *b*.	,,	,,	Upper surface, magnified one half diameter
2 *c*.	,,	,,	Under surface, do. do.
2 *d*.	,,	,,	Lateral view, do. do.
2 *e*.	,,	,,	Ambulacral area, poriferous zones, and one half of an inter-ambulacral area, magnified six times.
2 *f*.	,,	,,	Primary tubercle, magnified.
Fig. 3.	,,	,,	Spines, natural size.
Fig. 4.	,,	,,	Portion, magnified six times.



C. R. Bone del et lith

W. West imp

PLATE XXI B.

From the Red Chalk.

Fig. 1 *a*. Pseudodiadema Brongniarti, *Agassiz*. Cabinet of the Rev. T. Wiltshire, F.G.S. (P. 111.)

1 *b*. Lateral view of the same. Both natural size.

Fig. 2. Another specimen, belonging to C. B. Rose, Esq., F.G.S.

From the Grey Chalk.

Fig. 3 *a*. Pseudodiadema Brongniarti, *Agassiz*. Cabinet of the Rev. T. Wiltshire, F.G.S.

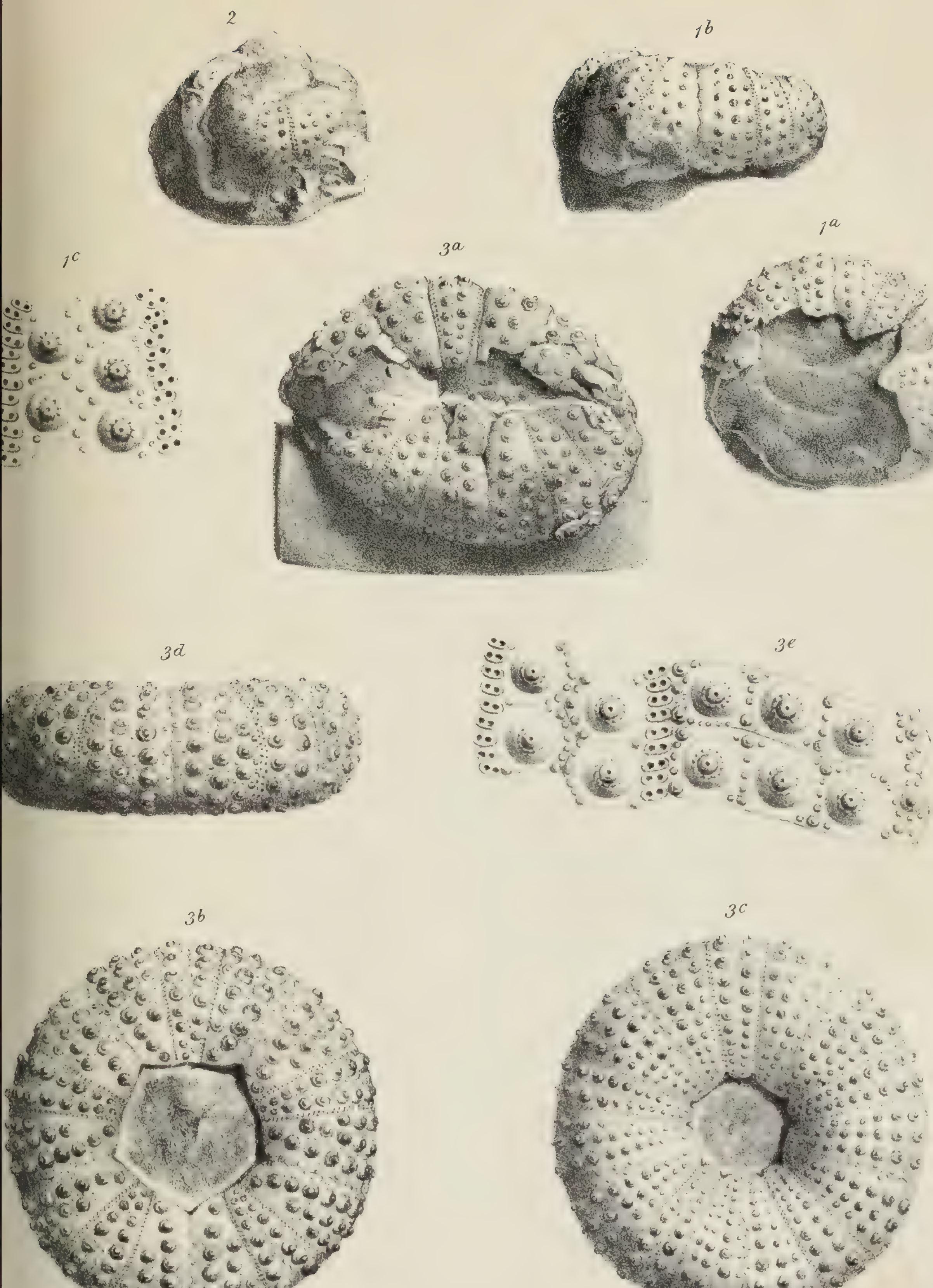
3 *b*. The test restored from this fine large specimen. Upper surface.

3 *c*. Do. do. do. Under surface.

3 *d*. Do. do. do. Lateral view.

3 *e*. Portion of the ambulacra, inter-ambulacra and pores, magnified four times.

Pl. XXI. B.



C R Bone del et lith

W West imp

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1867.

LONDON:

MDCCCLXVIII.

A MONOGRAPH

OF

THE FISHES

OF THE

OLD RED SANDSTONE OF BRITAIN.

BY

JAMES POWRIE, F.G.S.,

AND

E. RAY LANKESTER,

JUNIOR STUDENT OF CHRIST CHURCH, OXFORD.

PART I.—THE CEPHALASPIDÆ.

BY

E. RAY LANKESTER.

Pages 1—33; Plates I—V.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1868.

PRINTED BY J. E. ADLARD, BARTHOLOMEW CLOSE, E.C.

THE FISHES

OF THE

OLD RED SANDSTONE OF BRITAIN.

Part I.—THE CEPHALASPIDÆ.

INTRODUCTION.

I would here beg to claim indulgence for the deficiencies of the following pages relative to the Cephalaspidæ. These Fish I have had to treat *systematically* for the first time since the work of Agassiz; a great deal of the material submitted to me has been quite new; and, in addition to the absence of any previous essays on the Family (excepting occasional papers of great value, but of limited scope), the very special and peculiar nature of the fossils has been a source of some difficulty. The generic and other divisions which I have adopted have been taken simply with the view of exhibiting breaks in the continuity of forms; and they may of course, at any time, be bridged over by further discovery. At the same time, I believe that the grouping here offered furnishes the most convenient method of arranging these fragmentary remains. I may mention, that I feel sure, from various indications, that many new species are to be found in the very localities which have furnished those now known.

I take this opportunity of expressing my thanks to Professor Huxley for the use of a great number of specimens assembled by him for his own study, as well as of specimens in the Museum of the Survey; to my colleague, Mr. Powrie, of Reswallie, Forfar, who is engaged on another portion of this Monograph, for the use of his unique and beautiful specimens, and other kind assistance; to Dr. Grindrod, of Malvern; Mr. Humphry Salwey, of Ludlow; the Rev. P. B. Brodie; the late Mr. Wyatt-Edgell; Mr. Lightbody, of Ludlow; the Rev. J. Crouch; Mr. Salter; the Rev. Hugh Mitchell; Mr. Morton, of Liverpool; Dr. Harley, and others who have been kind enough to give their help in the communication of specimens and in other ways.—E. R. L.

THE CEPHALASPIDÆ.

We commence this work with the consideration of the Fishes belonging to the Family CEPHALASPIDÆ of Professor Huxley,[1] because they are the oldest Fishes the remains of which are known,—because these remains are of a special and peculiar nature, having very little in common with the remains of the other Fishes of the Old Red Sandstone,—and because a great deal of knowledge with regard to them has accumulated since the last work, treating of them as a group, was published, viz., Agassiz's 'Recherches,' dating from the year 1834.

§ I. *History of the Cephalaspidæ.*—In his great work, 'Recherches sur les Poissons Fossiles' (1835), Professor Agassiz established the genus *Cephalaspis*, to include four species of Devonian Fishes obtained in Britain. These species were respectively named *C. Lyellii*, *C. rostratus*, *C. Lloydii*, and *C. Lewisii*. The first was known to Prof. Agassiz by specimens both from the West of England and from Scotland; and two of these specimens showed, in addition to a large semicircular head-shield, the body covered with scales and provided with a well-marked caudal fin. The other species were known to him only by oval discoid bodies corresponding to the large semicircular head-plate of the first; but he was led to conclude that they were allied forms partly by real, partly by fancied resemblances in construction, and by their occurring under the same conditions. He remarked, however, very strongly on the differences between the first and the last of his species of *Cephalaspis*, and pointed out that, in addition to the differences in contour and shape, there were differences in minute structure and ornamentation, which would probably lead at some future time to a separation of the species into other genera.

In 1847 Dr. Rudolph Kner published a memoir in Haidinger's 'Naturwissenschaftliche Abhandlungen,' for the purpose of proving that *Cephalaspis Lewisii* and *C. Lloydii* were not the remains of Fish at all, but that they were the internal shells of a Cephalopod allied to *Sepia*, for which he proposed the generic title *Pteraspis*.

Dr. Kner's conclusions were based upon the examination of a fossil[2] (evidently closely allied to *C. Lloydii*) from the Upper Silurian (perhaps corresponding to our lowest Devonian) strata of Gallicia. The structure of the test in this fossil was observed by Dr. Kner to differ from that of any known osseous remains of Fishes; and he considered, from a somewhat superficial examination of both structures, that it agreed closely with the cuttle-bone of *Sepia*. (See also p. 12.)

In 1856 Dr. Ferdinand Roemer, in Dunker and Von Meyer's 'Palæontographica,'

[1] The Family CEPHALASPIDES of Agassiz included the Genera *Pterichthys*, *Coccosteus*, &c.

[2] Dr. Kner does not appear to have named this species, and I shall therefore hereafter speak of it a *Scaphaspis Knerii*. (See pages 19 and 20.)

described a fossil from the Devonian strata of the Laacher See as *Palæoteuthis,* referring it to the *Sepiadæ.* Professor Huxley has since shown this to be closely related to Agassiz's *Cephalaspis Lloydii.* Roemer, in referring to Kner's memoir, expressed the opinion that his *Pteraspides* were the remains of Crustacea.

Whilst matters stood thus with regard to the last two of Agassiz's species of *Cephalaspis,* Sir Philip Egerton described, in the 'Quarterly Journal of the Geological Society,' vol. xiii (1857), several new species by far more closely related to his *Cephalaspis Lyellii,* namely, *C. Murchisoni, C. Salweyi,* and *C. ornatus;* and further formed a new genus, *Auchenaspis,* for the reception of a very small form, which differed from *Cephalaspis Lyellii* in having the hinder portion of its shield separated as a distinct "neck-plate."

The genus *Menaspis* was briefly described (without any figure) by Ewald, of Berlin, in 1848; and was stated to have affinities with *Cephalaspis.* His description, however, by no means warrants this conclusion. The fossil was found in beds of Permian age.

In Russia (1854), Eichwald described a new genus and species allied to *Cephalaspis Lyellii,* but differing in having no orbital apertures, as *Thyestes verrucosus* (see fig. 7, p. 16), which Prof. Pander, in his 'Monographie der fossilen Fische des Silur-Systems' (1856), afterwards re-figured and described as *Cephalaspis verrucosus,* together with another species from the same locality (Rootsiküllc), the latter being termed *Cephalaspis Schrenkii.*

Mr. Banks, of Kington, in Herefordshire, now discovered two species of *Cephalaspidæ,* allied to *Cephalaspis Lloydii,* in the Downton Sandstone, and these were described by Professor Huxley and Mr. Salter, in the 'Quart. Journ. Geol. Soc., 1856,' as species of Kner's genus *Pteraspis.* At the same time these authors withheld their opinion as to the piscine, molluscan, or crustacean nature of the genus.

Shortly after this, in 1858, Professor Huxley published a most detailed and careful account of an inquiry into the intimate structure of the fossil shields forming Agassiz's genus *Cephalaspis,* with a view to ascertain the correctness of Kner's conclusions as to the nature of those species which he had separated as *Pteraspis.* This most valuable essay is contained in the 'Quart. Journ. Geol. Soc.,' vol. xiv, and I shall have to refer to it very largely hereafter. For the present, it is sufficient to say that Professor Huxley conclusively demonstrated that there was no foundation in facts for the supposed resemblance between *Pteraspis* and *Sepia,* or between it and any Crustacean armature. *Cephalaspis Lyellii* was shown to have a bony structure, from which truly *C. Lloydii* and Kner's species differed very widely, but not in such a manner as to render it probable that they were anything but the shields of closely allied Fishes. Kner's genus *Pteraspis* was therefore definitely adopted for the three latter species of Agassiz's genus *Cephalaspis,* and for the allied forms more recently discovered.

Another species of true *Cephalaspis* was next made known by Dr. Harley ('Quart. Journ. Geol. Soc.,' vol. xv, p. 503, 1859): and Mr. Salter in the 'Ann. Nat. Hist.,' July, 1859, described a *Pteraspis* occurring in the Upper and Lower Ludlow beds of the Silurian series, which is the oldest indication of a Vertebrate animal on record.

In the 'Quart. Journ. Geol. Soc.' for 1860 Professor Huxley published a paper in which he showed the true nature of Roemer's *Palæoteuthis* (see also fig. 10, p. 20), already alluded to, and at the same time gave a restored outline of the shield of the *Cephalaspis* (*Pteraspis*) *rostratus* of Agassiz.

In 1863 I had the good fortune to obtain a specimen of *Pteraspis*, showing a few rhomboid scales attached to the shield, and thus the piscine nature of the fossils was definitely set at rest. (Plate V, fig. 3.)

In 'Decade X' of the Geological Survey published in 1861, Professor Huxley constituted the family CEPHALASPIDÆ to receive the genera *Cephalaspis*, *Auchenaspis*, *Pteraspis*, and *Menaspis*. This family he placed among the Chondrostean Ganoids, where he considered it should have a very distinct position.

At the Meeting of the British Association at Bath, 1864, I proposed to divide the genus *Pteraspis*, as adopted by Professor Huxley, into three other genera, in accordance with three degrees of complexity in the structure of the head-shield observable in the known species: and in the following year, at Birmingham, I briefly reviewed the species of *Cephalaspis* then known, and exhibited specimens of these Fishes, of great interest, discovered by Mr. Powrie, in Forfarshire. Lastly, in the 'Geological Magazine' for April, 1867, I described the genus *Didymaspis*, allied to *Cephalaspis* and *Auchenaspis*.

The following list contains references to all, I believe, that has been written on the Fishes of the Family *Cephalaspidæ*, the titles of the papers being given in chronological order:

AGASSIZ. 'Recherches sur les Poissons fossiles,' vol. ii, p. 135, pls. 1*a*, 1*b*, 1835.

,, 'Monogr. Poiss. Vieux Grès Rouge,' p. 31, 1844.

KNER (*Cephalaspis Lloydii*, *C. Lewisii*, and a new species). Haidinger's 'Naturw. Abhandlungen,' vol. i, p. 109, 1847.

EICHWALD (*Thyestes verrucosus*). 'Bullet. Société Imp. Nat. Moscou,' p. 108, 1854.

EWALD (*Menaspis*). Proceed. Acad. Berlin, p. 33, 1848.

PANDER (*Ceph. verrucosus* and *C. Schrenkii*). 'Monographie der fossilen Fische des Silur-Systems,' p. 47, 1856.

HUXLEY and SALTER (*Pteraspis truncatus* and *Pt. Banksii*). 'Quart. Journ. Geol. Society,' vol. xii, p. 100, 1856.

EGERTON (*Ceph. Murchisoni*, *C. Salweyi*, and *C. ornatus*, and *Auchenaspis*). 'Quart. Journ. Geol. Soc.,' vol. xiii, p. 282, 1857.

HUXLEY (Structure, &c. of *Cephalaspis* and *Pteraspis*). 'Quart. Journ. Geol. Soc.,' vol. xiv, p. 267, 1858.

,, (Observations on *Pteraspis*). 'Brit. Assoc. Report,' 28th Meeting, Trans. Sect., pp. 82, 83, 1858.

HARLEY (*Ceph. asterolepis*). 'Quart. Journ. Geol. Soc.,' vol. xv, p. 503, 1859.

SALTER (*Pteraspis* from the Ludlow Beds). 'Annals and Mag. Nat. Hist.,' 3rd ser., vol. iv, pp. 44—48, 1859.

HUXLEY (*Palæoteuthis* and Restoration of *Pteraspis*). 'Quart. Journ. Geol. Soc.,' vol. xvii, p. 163, 1860.

,, (Zoological Position of *Cephalaspidæ*). 'Memoirs of Geol. Survey, Decade X,' p. 38, 1861.

Lankester (Scales of *Pteraspis*). 'Quart. Journ. Geol. Soc.,' vol. xx, p. 194, 1863.
" (On the Genera *Pteraspis*, *Cyathaspis* and *Scaphaspis*). 'Brit. Assoc. Report,' Trans. Sect., p. 58, 1864.
" (On the Genus *Cephalaspis*). 'Brit. Assoc. Report,' Trans., Sect., p. 65, 1865.
" (On *Didymaspis*). 'Geol. Magaz.,' April, vol. iv, p. 152, 1867.

Besides these papers, there are several Letters on the *Cephalaspidæ* in the pages of the 'Geologist,' 1858—64, by Messrs. Powrie and Marston, the Rev. Hugh Mitchell, and myself.

§ II. *Nature of the Evidence with regard to Cephalaspidæ now available.*—Though the knowledge of these Fishes has been gradually increasing, as may be gathered from the brief review above given of their literary history, and though we have now far more perfect specimens to examine than Professor Agassiz originally had, yet, except in the case of one or two species allied to *Cephalaspis Lyellii*, nothing whatever is known of the form of the body, position of the fins, or arrangement of the scales.[1] In every case with the exception mentioned, our knowledge of the Fish rests solely, as did that of Professor Agassiz, on more or less imperfect specimens of the oval, discoid, or semicircular shields which covered the anterior portion of the animal. Owing to this fact, the modifications in the form and structure of this cephalic shield are necessarily made the basis of the arrangement and classification of these Fishes; and, though those few specimens which exhibit a scale-covered body, fins, &c., possess a very high interest, they cannot to any large extent be made use of for the purpose of drawing conclusions with regard to the other Cephalaspids.

§ III. *Division of the Cephalaspidæ into two Sections.*—The genera *Cephalaspis* and *Pteraspis* into which Professor Huxley divided Agassiz's genus *Cephalaspis*, on account of remarkable differences in the histological character of the shields, each admits of subdivisions which perhaps might be viewed as sub-genera, but which, I think, it will be more convenient to regard as genera, adopting new names for the sections of the Family *Cephalaspidæ,* indicated by Professor Huxley's generic division. Thus I propose to call the Pteraspidian forms Heterostraci, in view of the special character of their test; the Cephalaspidian forms, Osteostraci, in reference to the occurrence of true bony structure in their cephalic shields. Each of these sections contains three or four genera of about equal value, all of which are very definitely distinguished, and nearly all embrace at least two or three species a-piece.

§ IV. *Nature of the Shields of Cephalaspidæ; and grounds for division into two Sections.*

[1] Professor Agassiz in his 'Monogr. de Vieux Grès Rouge,' published in 1844, remarked that the ten years that had passed since the publication of the 'Recherches' had not brought any fresh evidence to light as regarded the *Cephalaspidæ*.

The grounds upon which the division into Heterostraci and Osteostraci is based are derived chiefly from the intimate structure of the cephalic shields, though there are also other considerations in regard to the form of these shields which seem to warrant the arrangement. It is remarkable that, while in nearly all the Osteostraci (*Cephalaspis*, *Auchenaspis*, &c.) the orbits are large and placed near the centre of the shield, in the Heterostraci(*Pteraspis Scaphaspis*, &c.) there are either no orbits at all in the shield, or they are minute and placed marginally. This distinction is not, however, persistent, for in Eichwald's *Thyestes* (*Cephalaspis verrucosus* and *Ceph. Schrenkii* of Pander) there are, according to the figures given, no orbits excavated in the shield, although its structure is similar to that of *Cephalaspis*.

(*a*.) It will now be convenient to examine the question as to the structure of the shield in detail, in order to exhibit fully the reasons which have led to this division of the *Cephalaspidæ;* and, in so doing, I shall have to make most extensive use of Professor Huxley's memoir on this subject.

Professor Agassiz did not fail to perceive the differences in structure presented by his species of *Cephalaspis*. He thus describes the constitution of the cephalic shield in *C. Lyellii*:—" In *C. Lyellii* the head is covered with a pavement of polygonal plates altogether similar to that which covers the head of *Ostracion*. Each plate is convex in the centre, and is marked by radiating grooves ending at the margin in denticulations, by which the scales interlock. These scales appear to be osseous, and to have their external surface enamelled. At the circumference of the disc they become confounded together, and the enamel presents wrinkles parallel to the edge." Elsewhere these plates are said to be " true scales juxtaposed." In the 'Recherches,' M. Agassiz describes " fibrous bones of the head " under " the scales," and he particularly mentions and figures the radiating direction of these " fibres." This view of the composition of the shield in *C. Lyellii*, I need hardly say, has been shown to be erroneous. Professor Agassiz seems himself to have changed his opinion; for, in speaking of all four of his species together, he says—" It would appear from the condition of the specimens preserved, that all the cranial bones were only protecting plates which covered a cartilaginous cranium similar to that of the Sturgeons; at least, I have never been able to discover any cranial bones deprived of that characteristic granulation which indicates that the plates were in direct relation with the integument. Therefore, I think there can be no doubt that all these granular plates rested by their inner and smooth surface on a cranial cartilage, such as is found in Cartilaginous Fishes and in the embryos of Osseous Fishes."—*Monog. Grès Rouge.* He still seems to have entertained the idea that the shield was composed of a number of minute plates, though he abandons the notion of the existence of a subjacent osseous skull, and regards the shield as a tegumentary ossification.

The shield of *Cephalaspis Lloydii* Professor Agassiz described as consisting of an external striated enamel, of a middle layer " composed of granules similar to those of Chondropterygious Fishes," and of an internal layer made up of superimposed lamellæ.

Dr. Rudolph Kner describes the structure of his *Pteraspis* from Gallicia as follows:— "The form of the fossil is very similar to that of *C. Lloydii;* but it is larger, having a length of about four inches by a width of two. It consists of three layers. The innermost is shining, bluish-green, enamel-like, and presents four or five distinct lamellæ. This layer forms one continuous surface, marked in the centre by a longitudinal depression smaller at one end than the other, and by obscure radiating lines. The upper part of the conical depression is covered with minute pores or depressions, which are visible in the deeper as well as in the more superficial layers, but become evanescent in its lower part. Between the layer of enamel and the prismatic part which succeeds it, there lies a thin dull layer, in some places of a brownish colour. This is followed by an excessively delicate lamina of enamel which lies upon the prisms. The layer of prisms is one line thick, and in section presents a number of more or less hexagonal discs. The enamel passes for a short distance between the prisms. Externally the prisms lie on a granular layer, to which the outermost very delicate epidermic lamina marked with parallel striæ succeeds." Such was the structure which Dr. Kner believed he had seen in his *Pteraspis,* and compared with that of the Cuttle-bone, to which it really presents but a superficial resemblance. It was on account of this structure that Dr. Kner proposed to remove *Cephalaspis Lloydii* and *C. Lewisii* from the Class of Fishes, and place them with his new form as *Pteraspis* among the Cephalopodous Mollusca.

Professor Pander describes briefly the structure of the Russian *Cephalaspidæ* (*Thyestes*) in his work already quoted, from which it is evident that they have very little in common with *Pteraspis.* Sections of tubercles from the margin of the shield exhibited "a homogeneous base, in which clear and dark cells of the most various forms (rounded, elongated, and angular, with fine radiating branches) lay scattered, and were frequently disposed in concentric layers, where a tubercle rose above the general surface. Although they have not the same general form as ordinary bone-lacunæ (such as occur in *Pterichthys* and *Coccosteus*), yet they can hardly be called by any other name."

Professor Huxley, from whose memoir the above account of his predecessors in this inquiry is chiefly quoted, has left very little to be added to his exhaustive description of the structure of the shield in *Cephalaspis Lyellii* and *C. Lloydii.* I have examined the structure in *Cephalaspis Murchisoni* and in *C.* (*Pteraspis*) *rostratus,* and have nothing of importance to add, but am able to confirm his description from the examination of a very large number of specimens. Taking then, first, *Cephalaspis Lyellii* and its allies representing the OSTEOSTRACI, we will return afterwards to *Cephalaspis Lloydii, C. rostratus,* &c. (Kner's *Pteraspides*), typical of the section HETEROSTRACI.

A naked-eye examination of the shield of *Cephalaspis Lyellii* shows in most specimens that deceptive apparent division of the outer surface into polygonal scales described by Professor Agassiz. In some curiously preserved specimens of a species from Scotland I have observed the divisions really existing, the upper surface of the shield being split up into polygonal pieces like a tesselated pavement. In other species, however, from England

(*C. ornatus*, *C. Salweyi*), the outer surface, if well preserved, and not broken away as it usually is in *C. Lyellii*, shows a continuous polished surface ornamented with tubercles and papillæ variously disposed, without any indication of a tesselated structure. In all species of *Cephalaspis*, in *Auchenaspis*, and *Thyestes*, this tuberculate ornamentation on a continuous polished surface is an unmistakeable naked-eye character of the shield. As regards the internal surface in *Cephalaspis Lyellii* and the allied species, it never exhibits any trace, when properly preserved, of the apparent tesselated structure seen when the external surface has been to a certain extent removed. It appears smooth, polished, and enamel-like, excepting where it is furrowed by numerous shallow depressions which radiate from the region of the orbits and occiput towards the margin, before reaching which they repeatedly subdivide and anastomose. There can be little doubt, Professor Huxley observes, that these are the impressions of the vessels which ramified under the disc during life. These radiating channels leave their impress in the convex coats of the interior of the shield, and it was their occurrence which led Professor Agassiz to speak of "fibrous bones." In those forms allied to *C. Lyellii*, but differing in having the shield divided antero-posteriorly into two plates, the anterior plate alone shows these radiating channels; and, indeed, they are often deficient in the posterior part of the shield of true Cephalaspids. The inner surface of the shield in *Thyestes* is not known. This radiated channeling of the internal surface of the shield may therefore be taken as a constant character in *Cephalaspis Lyellii* and its congeners.

When a vertical section is made through the shield in *Cephalaspis Lyellii*, it is seen to be exceedingly thin, scarcely anywhere exceeding the $\frac{1}{40}$th of an inch in thickness, excepting at the margins and spine; it appears to the naked eye to consist of a compact white calcareous substance. The shield in *C. Salweyi*, *C. asterolepis*, and others, is not so thin, and the posterior plates of those species which possess them are also much thicker than the anterior orbit-bearing portions.

If the section of *C. Lyellii* be now prepared and placed beneath the microscope, the appearances thus described by Professor Huxley[1] as visible in a section near the spine are observable[2]:—The section "presents three regions or layers, distinguishable from one another partly by their minute structure, and partly by the different mode of distribution of the vascular canals by which the tissue is permeated in each. The innermost or deep layer is made up of superimposed lamellæ, not more than $\frac{1}{2000}$th of an inch thick, each of which sometimes appeared to be still more finely laminated. Interspersed among these, at greater or less distance, are numerous osseous lacunæ, whose long axes are parallel with the planes of the laminæ. The length of these lacunæ varies greatly, but may be taken at $\frac{1}{2000}$th of an inch on the average; some, however, are twice or three times this length, while others are much less. The transverse diameter is equally variable; but

[1] 'Quart. Jour. Geol. Soc.,' vol. xiv, p. 271, &c.

[2] The illustrations of the microscopic structure of the Osteostraci will appear in the next portion of this Monograph, which will treat of that Section.

none that I measured exceeded $\frac{1}{3000}$th of an inch in this direction. The form of the lacunæ is very irregular, in consequence of the long branching and anastomosing canaliculi which are given off, not only from their ends, but from their sides. In some parts the innermost layer appears almost black when viewed by transmitted light, in consequence of the quantity of air retained in the multitudinous lacunæ and canaliculi. Large vascular canals, measuring from $\frac{1}{200}$th to $\frac{1}{400}$th of an inch in diameter, whose inner openings correspond with brown spots distinctly visible on the inner surface of the shield, traverse the innermost layer very obliquely in their course towards the middle layer. Their branches are few, and for the most part run parallel with the main trunk; but they give off a great number of minute canaliculi which anastomose with those of the nearest lacunæ. Such of these canals as I have seen in section were oval, their long diameters being parallel with the planes of the lamellæ. . . . . The middle layer is distinguished from the inner by the rarity or entire absence of the lacunæ, and by the indistinctness of the lamination as compared with that of the deep layer. Such striations of the nearly homogeneous base as seem to indicate lamination are, in the middle and inner parts of the middle layer, so disposed as to be nearly perpendicular to those of the deep layer, appearing to follow the course of the vascular canals. The latter are continuous with the large vascular canals of the deep layer, but they are smaller, and form a close network. Each of the large canals, on reaching the middle layer, gives off several branches, which run nearly parallel with the surface (and therefore greatly inclined to the course of the great canals), and anastomose with those around, above, and below them. In this particular part of the disc, in fact, a large canal gives off as many as three tiers of these lateral branches, separated from one another by not much more than their own diameter, and all ramifying and anastomosing with one another. These lateral vascular canals have at first a diameter of about $\frac{1}{900}$th of an inch; but many of their anastomotic branches are much smaller. Sooner or later all these branches appear to end in a close 'superficial network,' which lies in the boundary between the middle and the superficial layers. The latter or third layer of the disc sometimes appears structureless, at others presents an obscure vertical striation, as if it were, like enamel, made up of minute fibres. The superficial vascular network sends into it a great number of minute short processes, which branch out abruptly at their ends, like a thorn-bush or standard rose-tree, and end in excessively fine tubuli, like those of dentine.[1] . . . . This substance, it will be observed, corresponds very closely in structure with the 'cosmine' of Professor Williamson. I have been unable to find any trace of a 'ganoin' layer external to it."

A structure in every essential respect similar to this is found in all the other regions of the cephalic shield, the three layers varying somewhat in relative thickness. When flakes of the inner layer are detached and examined, the axes of the lacunæ of each lamina are seen to be directed nearly at right angles to those of the laminæ above and below;

[1] In those species in which the tubercles are well marked, it is seen that a "bush" of fine tubuli forms the centre of each tubercle.

so that under a low power the section appears to be cross-hatched by a series of dark lines. "In flakes of the disc similarly treated, but containing more of the middle and outer layers, it is obvious that the great canals divide into the branches of the middle layer, which have already been seen in the vertical section, chiefly, if not only, along lines corresponding with the apparent sutures of the so-called 'polygonal scales.' The canals of the middle layer are very singularly arranged, passing from their origin, across these sutural lines and nearly parallel with one another, towards the centre of the adjacent 'scales.'"[1] This, then, is the cause of the appearance of a division of the external surface into distinct scales; the minute canals, with their reddish infiltration of matrix, showing very distinctly against the lighter general substance, or even allowing the shield to crack along these lines.

It is worth noting, in addition to this, that the more superficial parts of the hard calcareous matter in each of these apparently polygonal scales has a radiated fibrous arrangement, the fibres diverging from the centre. This fibrous structure is visible in many specimens of *Cephalaspis* from the Cornstones of Herefordshire.

(*b.*) We now turn to the other members of the family *Cephalaspidæ*, typified by Agassiz's *C. rostratus*, *C. Lloydii*, and *C. Lewisii*, embraced by Kner's genus *Pteraspis*, and forming my Section Heterostraci.

A naked-eye examination of suitable specimens of any of these shields shows the exterior surface to have a very peculiar ornamentation: instead of enamel-like tubercles, minute ridges and grooves, running parallel to and concentrically with one another, everywhere mark the convex superficies. These ridges are exceedingly small in some species, and vary in different forms from $\frac{1}{50}$th inch or larger to $\frac{1}{200}$th of an inch in breadth: they are usually crenated at the margins, and give the notion, in some species, of a linear series of minute tubercles fused together. They may not unfittingly be compared to the markings of the epidermis on the palms of the hand and fingers in Man and other Primates. The inner surface of the shield is seen to be quite smooth and polished, and exhibits no vascular channels, as in *Cephalaspis Lyellii*, but a few irregular ridges of some size, diverging from the centre of the scute or running parallel to the margins, having the aspect of lines of growth. Scattered rounded apertures are to be detected on this smooth inner surface, not above $\frac{1}{400}$th of an inch in diameter. If a vertical section is now made through the shield, or if it be judiciously broken, the structure of the interior becomes obvious. Firstly, the thickness of the 'shell' in most places is greater than in specimens of *Cephalaspis* of the same size, being frequently more than $\frac{1}{40}$th of an inch, and in terminal portions (such as the margins, spine, or rostrum) much thicker. The most striking feature, however, which comes to view is the separation of the material of the inner and outer surface of the shield by a stratum of polygonal cavities, sometimes filled up by the infiltration of carbonate of lime, and having the appearance of

[1] Op. cit., p. 273.

prismatic bodies.[1] The innermost of the layers is a solid laminated stratum, having somewhat the appearance of the nacre of molluscan shells, whence Professor Huxley has termed it the 'nacreous layer;' a few vascular canals pass through it, opening by the minute apertures mentioned as apparent on the inner surface of the shield. The middle layer which consists of the polygonal cavities, is formed by vertical processes of the laminated substance of the innermost layer; these vertical plates are so disposed as to form a network enclosing polygonal (4-, 5-, 6-sided) cells, described by Professor Huxley in *Pt. Banksii* as having an average diameter of $\frac{1}{50}$th of an inch. The septa forming the vertical walls of the 'cavities' bend over to complete their enclosure above, and are thus connected with the outer layer—that which is produced into ridges. This general structure is common to all those species of Agassiz's *Cephalaspis* which have been separated as *Pteraspis*.

Professor Huxley minutely describes and illustrates the microscopic appearances of this structure, as seen in a section of the shield of *Pt. Lloydii*. The most important fact to be observed in this and *Pteraspis rostratus*, which I have examined, is the total absence of 'bone-lacunæ,' or anything like them. The three layers—the outer or 'striated,' the middle or 'cancellated,' and the inner or 'nacreous'—consist of a continuous finely laminated material. The laminæ in *Pt. Lloydii*, Professor Huxley says, have a thickness of about $\frac{1}{4300}$th of an inch. The inner layer consists of nothing but a compact mass of these laminæ arranged horizontally; it is totally devoid of vascular canals or tubules, excepting where here and there a canal of some size passes from its aperture upwards into the walls of the next layer. The laminæ are arranged concentrically round the cavities in the middle layer, and large canals, about $\frac{1}{400}$th of an inch in diameter, pass along these walls towards the upper layer. In some cases these canals appear to open from the polygonal cavities; in other cases they come directly from their apertures on the inner surface of the shield. In the upper wall of the stratum of polygonal cavities the canals take a horizontal direction, still very few in number and of large size, receiving here, undoubtedly, branches from the cavities. The calcareous laminæ are here arranged horizontally. Passing onwards to the uppermost layer, if the section has been made transversely to the surface-ridges, these appear in section as so many papilliform processes; if the section has been made along one of the ridges, a continuous horizontal layer is exhibited. Into this layer, or into these papillæ, the horizontal canals send short branches (one to each papilla), which give off minute tubules in every direction; these arborescent tufts correspond to the vascular bushes in the external layer of *Cephalaspis*.[2] The

[1] Mr. Edward Fielding, the artist who has so well executed the plates of this part of the Monograph, has been obliging enough to make a chemical analysis of specimens of *Pteraspis* from the Cornstones of Herefordshire. He finds that the substance of the fossil itself is almost entirely phosphate of lime, whilst the material sometimes filling the polygonal cavities is carbonate of lime.

[2] In the Devonian species of *Heterostraci* each enlargement of the doubly crenated ridge seems to correspond to a tubercle of *Cephalaspis*, having a vascular tuft for its axis.

laminated material is arranged round these tufts concentrically, the finer branches traversing it, much in the same way as dentinal tubules traverse dentine. Indeed, each of the sections of the ridges recalls very strongly the structure of a tooth or of a dermal defence of a Placoid Fish. There is no trace of a 'ganoin' layer beyond the laminated material forming the ridges; but it is noticeable that the outermost laminæ in specimens from the Cornstones acquire a pinkish-brown colour distinct from the rest of the shield, and readily scale off. In some species this outermost surface is dull; in others it is brilliant and polished. The fact of the distinct colour of this outermost part of the outermost layer, together with its tendency to separate, might lead to the impression that we have here a 'ganoin' layer; no such layer, however, is to be detected with the microscope.

The absence of bone-lacunæ, the paucity of vascular canals, and the excavation of the mid-layer of the shield into large vascular sinuses, cannot be too strongly insisted on as the characteristic structure of these shields.

Professor Huxley obtained from Sir Philip Egerton specimens of Kner's *Pteraspis* from Gallicia, and most completely reconciled the German palæontologist's description of the fancied resemblances to the Cuttle-bone with the true structure of the shield as he had ascertained it from English specimens. Kner's 'innermost layer' is obviously the 'nacreous layer' described by Huxley; the 'prismatic layer' is formed by the polygonal cavities of the middle layer, which have become infiltrated with probably carbonate of lime, as in many examples from Britain; the striated layer undoubtedly corresponds to the outer layer in our Fish, and the identity in structure is complete.

The chief differences, then, between these two sets of shields in their minute structure consist—first, in the absence of osseous lacunæ in the Pteraspidian forms, their presence in the Cephalaspidian[1] forms; secondly, in the different general character and arrangement of the vascular sinuses; thirdly, in the different mode of arrangement of the external layer, which is, it seems, invariably marked with fine long ridges in the former, with minute tubercles in the latter.

(*c.*) The Pteraspidian forms present such marked differences among themselves in the *form* of their shields, that it would be inconvenient to retain them in one genus; the same is true of the Cephalaspidian forms: hence I have adopted the Section Heterostraci (ἕτερος, of another kind; ὄστρακον, a shell or dermal bone) for those with the peculiar structure of *Pteraspis;* and the Section Osteostraci (ὀστέον, bone) for those with the bony structure of *Cephalaspis Lyellii.* There are other characters which separate these two Sections; as, for example, the disposition of the orbits mentioned above.

It is interesting to observe that each of the Sections presents a genus in which the shield is composed of a single simple piece: in the Heterostraci this shield presents no trace of orbits, but is a simple discoid body (*Scaphaspis*): in the Osteostraci the simple shield has large diverging appendages (cornua), and mainly consists of an orbital

[1] I have ascertained the presence of bone-lacunæ in *Auchenaspis* and *Didymaspis,* genera allied in external character to the type *Cephalaspis Lyellii.*

region, the eyes being placed centrally. In those genera of Heterostraci which develop a more complex shield the evolution shows itself in the enlargement of the anterior region, into a rostrum, orbital pieces, &c. In those Osteostraci which exhibit a shield of more than one piece the complexity results from the diminution of the orbital region and cornua, and the development of a large posterior plate, which is represented by only a small portion of the simple shield.

§ V. *Zoological Position.*—Whilst no one has ever doubted that *Cephalaspis Lyellii* and its allied forms are Fishes, in the face of the specimens showing the body and fins, the *Heterostraci* have been sometimes regarded as Cephalopods and Crustacea as related above. After his examination of the structure of *Pteraspis*, Professor Huxley remarks[1]—" No one can, I think, hesitate in placing *Pteraspis* among Fishes. So far from its structure having ' no parallel among Fishes,' it has absolutely no parallel in any other division of the Animal Kingdom. I have never seen any Molluscan or Crustacean structure with which it could be for a moment confounded." He is then led to conclude that *Pteraspis* is a Fish from its close relation in structure to *Cephalaspis*. Above, the differences between the two have been dwelt on; the resemblances have to be noticed as forming the original reason for retaining *Pteraspis* among Fishes. In each the shield is excessively thin, and composed of three or four layers: 1st, an 'internal,' composed of lamellæ parallel with the surface, and traversed more or less obliquely by vascular canals; 2nd, next to this a ' middle layer' containing the network of wide canals, or polygonal sinuses, the upper floor of which forms a 'reticular layer' in *Pteraspis;* 3rd, the 'external layer,' consisting of a cosmine, like substance raised into ridges or tubercles. Later conclusions as to the form of the shield in some Heterostraci, and the discovery of the scales of one species, have rendered the piscine nature of *Pteraspis* undeniable.

With regard to the relations of the family *Cephalaspidæ* to other groups of Fishes, I cannot do better than quote the opinion of Professor Huxley, the only one current at the present time on the subject. It must be borne in mind in connection with this question, that no indication whatever of an internal skeleton belonging to these Fishes has been found; and that specimens showing the body of *Cephalaspis* prove by negative evidence that such a structure did not exist. While assigning a distinct family to the genera *Cephalaspis*, *Pteraspis*, *Auchenaspis*, and *Menaspis*, he remarks:[2] " No one can overlook the curious points of resemblance between the Siluroids, *Callichthys* and *Loricaria*, on the one hand, and *Cephalaspis* on the other, while in other respects they may be still better understood by the help of the Chondrostean Ganoids. Compare, for example, *Scapirhynchus* with *Cephalaspis*, or the great snout of *Pteraspis* with that of *Spatularia*. I am inclined to place the *Cephalaspidæ* provisionally among the *Chondrostei*, where they will form a very distinct family."

[1] Op. cit., p. 277.

[2] 'Memoirs of the Geol. Survey of Great Britain, Decade X,' p. 38.

§ VI. *Distribution of Cephalaspidæ.*—There is not enough known with regard to these Fishes to warrant any conclusions as to their distribution in time or space. The facts are these: first, as to time—Cephalaspids occur in the Lower Ludlow beds, in the Upper Ludlow beds, in the Downton Sandstone, in beds called Upper Silurian in Russia and Gallicia, in the Ludlow Bone-bed, in the Passage-beds, and in that lowest portion of the Old Red Sandstone, which some geologists think ought to be called Silurian.

As to distribution in space: they have been found in the West of England, in the East of Scotland, in Russia at Rootsiküllе, in Gallicia, and in the Eifel. There is reason to hope that they may be found in North America, and other localities where Silurio-Devonian beds occur.

There is not satisfactory evidence that the same species of *Cephalaspidæ* occur in any two of the above-named localities. The species of the West of England appear to be distinct from those of Scotland; and even in the Cornstones of Herefordshire and Worcestershire the species appear to have the most limited range and definite horizons.

§ VII. *Synopsis of the Divisions of the Cephalaspidæ.*

Familia vel Sub-ordo CEPHALASPIDÆ, *Huxley.*

Pisces sine ossibus internis; *caput* scuto calcareo magno simplice vel composito armatum: *truncus* parvus, caudiformis, lepidibus rhombicis magnitudine variantibus ornatus.

Sectio A.—HETEROSTRACI.

Scuti materia sine "lacunis" osseis, intime sinibus polygonalibus excavata, superficie striis vel liris ornatâ.

Genus 1. *Scaphaspis.*—Scutum simplex ovale.

Genus 2. *Cyathaspis.*—Scutum in quatuor partes divisum, ovale.

Genus 3. *Pteraspis.*—Scutum in septem partes divisum, sagittiforme.

Sectio B.—OSTEOSTRACI.

Scuti materia "lacunis" osseis et tubulis vascularibus numerosis instructa, superficie tuberculis ornatâ.

a. Oculis in medio scuto positis.

Genus 1. *Cephalaspis.*—Scutum simplex semicirculare, cornubus lateralibus instructum.

Genus 2. *Auchenaspis.*—Scutum in duas partes, anteriorem et posteriorem divisum; anterior major, cornubus lateralibus instructa.

Genus 3. *Didymaspis.*—Scutum in duas partes, anteriorem et posteriorem divisum; anterior minor, sine cornubus lateralibus.

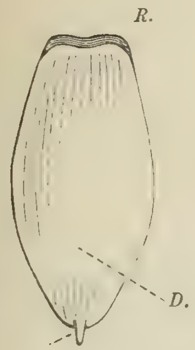
β. Oculis extra scutum positis (?).[1]

Genus 4. *Thyestes.*—Scutum simplex cornubus lateralibus parvis instructum.

FIGS. 1—7. *Diagrams of the Shields of the several Genera of the* HETEROSTRACOUS *and* OSTEOSTRACOUS CEPHALASPIDÆ.

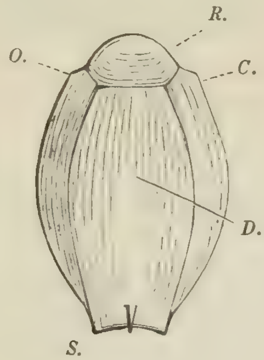
R. **Rostrum, or Rostral region.** ***C.*** **Cornua.** ***D.*** **Central disc, or Discal region.** ***S.*** **Posterior spine.** ***O.*** **Orbits.**

FIG. 1.



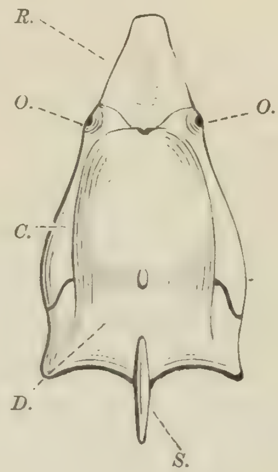
SCAPHASPIS.

FIG. 2.



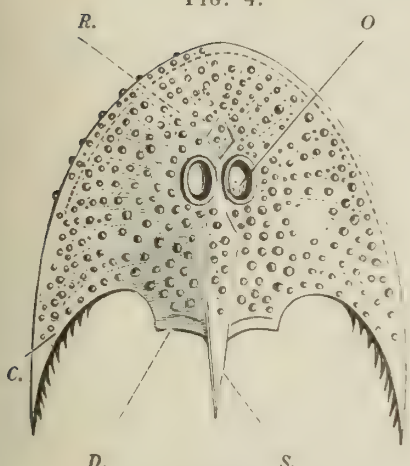
CYATHASPIS.

FIG. 3.



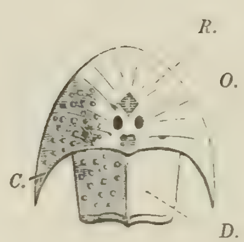
PTERASPIS.

FIG. 4.



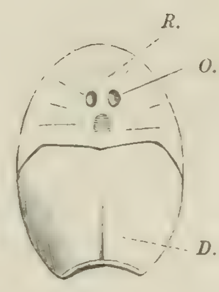
CEPHALASPIS.

FIG. 5.



AUCHENASPIS.

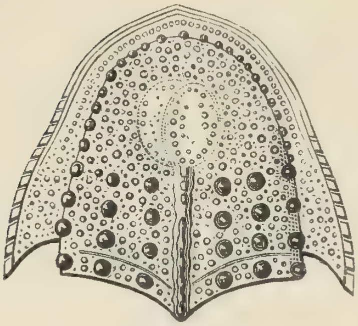
FIG. 6.



DIDYMASPIS.

[1] The evidence as to the deficiency of the orbits in *Thyestes* is not very satisfactory. Should the Russian *Cephalaspidæ* prove to have had their orbits placed mesially, the central position of the eyes would become a common character of the OSTEOSTRACI. *Thyestes* might then be retained for a genus, allied to *Cephalaspis*, in which the posterior spine and cornua are rudimentary. Sir Philip Egerton's *Cephalaspis Murchisoni* might then be joined with the Russian species in this genus.

Fig. 7.



Thyestes.

§ VIII. *Sectio* A.—Heterostraci.

Before proceeding systematically to describe the genera and species of Heterostracous Cephalaspidæ, illustrated in the Plates, it is necessary to say a few words with regard to the generic divisions given in the Synopsis above, and the resemblances and differences which the groups exhibit. It will be observed that the division into genera is based on the greater or less complexity of construction of the shield, it being stated to be simple in the first genus, composed of four pieces in the second, and of seven in the third. The nature of this separation into pieces is a question of some importance, which must be considered, as well as the limits of variation in ornamentation, and other matters.

1. *Variations in the Intimate Structure.*—The variations in intimate structure in the shields of *Heterostraci* are unimportant. As far as they have been examined in this respect the differences are merely in size, in the thickness of the layers, dimensions of the polygonal cavities, &c., which have been fully described (pages 10—12).

2. *Variations in the Surface-markings.*—The highly characteristic striations of the shield in *Heterostraci* vary considerably in different species. In all they bear a definite relation in their disposition to the outline of the plate or piece of the shield which they mark, each addition to the size of the plate appearing to result from the addition of new ridges parallel to and representative of those which have preceded. In this way the oval scutes become marked by a concentric series of oval groovings of greater or less regularity, whilst the distinct portions of the scute in *Cyathaspis* and *Pteraspis* show a regular consecutive series of transverse or curved markings. The grooves and their interjacent ridges vary in size in different species, from 50 to 200, or even more, going to the inch. The form of the ridges varies; some species presenting a flat-topped ridge, others a rounded one. In some species the inner sides of the ridges are crenated, in others smooth, whilst in one species there are ridges of large size interstriated by much smaller ones.

Other markings than these regular ridges are to be noticed, as common to these fish-shields. In some of those with an oval shield of simple construction, the frontal margin is a little thickened, and irregularly marked by coarse serpentine groovings. Besides this, an important piece of evidence with regard to the living condition of the scutes is furnished by the presence of small depressions or "pits" arranged in series on the striated surfaces diverging from the centre. These pits bear all the appearance of being the positions or sites of mucous glands, such as are abundant in all Fishes, and from them we may conclude that a secreting membrane was closely attached to the striated calcareous material.

3. *Variations in the Form and Construction of the Shield.*—In all the *Heterostraci* the shield is markedly concavo-convex, the lateral convexity being greatest. The margins are slightly inflected in all,[1] and thickened, especially where there is a posterior spine developed, or an anterior rostrum. In the Osteostracous genus *Cephalaspis* the anterior margin of the shield is inflected to a larger extent and thickened into a well-marked and strong "rim." In *Pteraspis* the rostrum is thick, strong, and solid, as also the posterior spine and lateral margins forming the "cornua"; they are striated on the under as well as the upper surface, and evidently projected to some extent beyond the softer portions of the animal covered by the curved shield.

In the simplest genus, *Scaphaspis*, the shield is composed of a single piece, of an oval shape, usually terminating acutely or in a short spine. In the most complex it is formed by the coalition of an anterior rostrum, two orbital pieces, a large central disc, two lateral perforate cornua,[2] and a posterior spine (see fig. 3, page 15). The genus *Cyathaspis* is intermediate between these two; it presents a short rostrum, two lateral cornua, and a central disc. By the aid of this form of shield, it is perceived that the anterior transversely marked margin of the shield in *Scaphaspis* represents the "rostrum" of the two other genera, which in *Cyathaspis* is much reduced; at the same time the acute termination of the shield (or spinous tubercle) typifies the large posterior spine of *Pteraspis*.[3] It is interesting to note the gradual development from the simple to the complex form in these shields (the differentiation accompanied with integration), and it is much to be desired that renewed researches may bring to light additional intermediate forms to complete the connection.

The pieces making up the complex shields are not actually separate. They form one continuous whole, but are distinctly emarginated by grooves and differing convexity.

[1] The lateral cornua in the genus *Pteraspis* are greatly thickened and inflected at the margin, forming, indeed, hollow dilated rims to the shield, which are perforated on each side. It is very difficult to find any explanation of these open excavated structures, unless they be "spiracles." See fig. 3, p. 15, and Plate VII, figs. 8, 9, 16, 17.

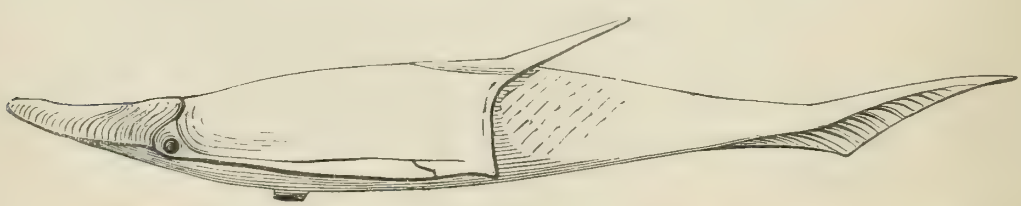
[2] The separation of the orbital pieces from the lateral cornua in *Pteraspis* is not quite satisfactorily ascertained.

[3] The simple ovoid scutes of *Scaphaspis* (*Cephalaspis Lloydii*, &c., of Agassiz) have been sometimes regarded by local collectors and others, as the "torsos" or central portions of the apparently more complete *Pteraspis*. This idea is, however, clearly shown by well-preserved specimens to be erroneous.

Each piece has its own series of striations, and on the smooth concave surface of the shield exhibits an apparent line of juncture with its neighbouring piece, in the form of an irregular rounded ridge. The pieces are in fact fused at their margins; they were, there is reason to believe, distinct when the Fish was young; and specimens of small central discs and rostra of *Pteraspis* occur unconnected and separate: when growth was completed anchylosis took place, and the pieces formed a single united shield. The unmistakable appearance of each piece having had a separate development and growth exhibited by the concentric markings and irregularities of form in complete shields of *Pteraspis*, when considered together with the presence of the ridges formed by the fused margins of the different pieces, seems to point to the conclusion that they were once unconnected and separated. It may be said, that if these pieces originated by separate development they would be united, not by a fusion of their margins, marked by an elevated ridge, but by sutures. In reply to this, I must call to mind the peculiar nature and histological structure of the calcified shield; besides which anchylosis occurs in the head-bones of living Ganoids (*Polypterus*), leaving a straight, elevated ridge as its indication. It does not appear that there is any reason to suppose that the union of separate pieces in *Pteraspis* would have occurred otherwise than in the manner indicated; and hence, I believe, I am justified in regarding the demarcated portions of the shield in *Cyathaspis* and *Pteraspis* as separate calcifications.

4. *Scales of Heterostraci.*—All that is known as regards the scales of these Fishes is from a single specimen found in the Cornstones of Herefordshire, which shows a few nearly equilateral rhomboid scales, ranged behind the posterior portion of a head-shield. It is probable that all Heterostraci possessed scales of this form, and very possibly others larger as well.

FIG. 8. *Diagram of* PTERASPIS, *showing both Shield and Body.*



5. *Hypothetical Form of the Body; Position of the Mouth, &c.*—The Woodcut, fig. 8, gives a purely hypothetical view of a species of *Pteraspis.* It has been introduced to exhibit the probable position of the shield and the form of the body. We *know* absolutely nothing of these matters; but it appears highly improbable (by the absence of such remains) that the mouth of this Fish was provided with hard teeth, or in fact was anything more than a suctorial organ; and there is reason to believe that what is known with regard to *Cephalaspis* as to the shape of the body is true to some extent for the parallel Heterostracous forms.

6. *List of Species of* HETEROSTRACI, *arranged in Order of their Occurrence.*

LOWER LUDLOW BEDS. *Scaphaspis Ludensis,* Salter.
UPPER LUDLOW BEDS. „ „ „
DOWNTON SANDSTONE. *Scaphaspis truncatus,* Huxley and Salter; *Cyathaspis Banksii,* Huxley and Salter.
LUDLOW BONE-BED. *Scaphaspis Ludensis?,* Salter; *Scaphaspis truncatus,* Salter.
UPPER SILURIAN (Gallicia). *Scaphaspis Knerii,* Lankester.
LOWER DEVONIAN (of the Eifel). *Scaphaspis Dunensis,* Rœmer.
CORNSTONES (West of England). *Scaphaspis Lloydii,* Agass.; *Scaphaspis rectus,* Lankester: *Cyathaspis Symondsi,* Lankester; *Pteraspis rostratus,* Agassiz; *Pteraspis Crouchii,* Salter.
LOWER OLD RED SANDSTONE (Forfarshire). *Scaphaspis,* sp., *Pteraspis Mitchelli,* Powrie.

7. *Descriptions of Genera and Species.*

Genus 1.—SCAPHASPIS, *Lankester.* British Assoc. Report, Trans. Sect., p. 58, 1864.

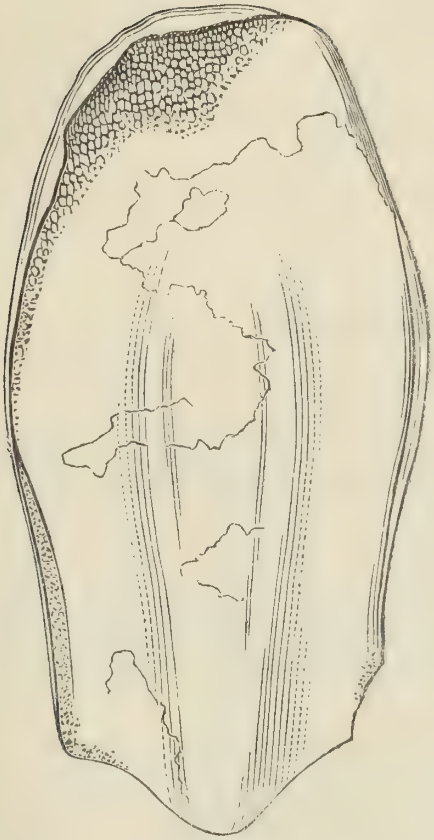
CEPHALASPIS (LLOYDII et LEWISII), *Agassiz.* Poissons fossiles, vol. ii, p. 149, 1835.
PTERASPIS (LLOYDII et LEWISII), *Kner.* Haidinger's Naturw. Abhandl., vol. i, p. 159, 1847.

Derivation.—σκάφη, a boat; ἀσπίς, a shield.

Characters.—Scutum cephalicum simplex, ovale, elongatum; postice aliquanto attenuatum et fere brevispinosum; superficie striis et liris longitudinalibus ornatâ antice transverse dispositis.

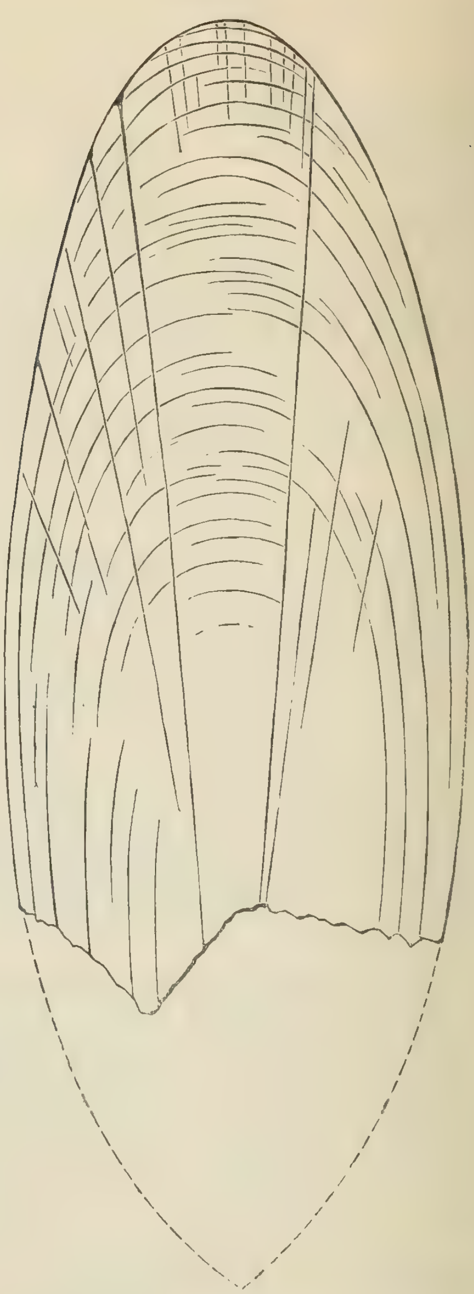
General Remarks.—This genus includes all the Heterostraci with a simple oval or elongate shield consisting of but one piece. It is the earliest to appear, occurring in the Lower Ludlow beds of the Silurian system. Of its British species two are Silurian, two Devonian. Two species have been described from Continental localities—one by Rœmer from the Laacher See, in the Eifel; the other from Gallicia, by Kner. The beds in which these occur may correspond either to our Lowest Old Red or Upper Silurian deposits. These two foreign species exhibit the characters of the English species in an exaggerated form. *Scaphaspis Dunensis* of Rœmer (p. 20), from the Eifel, groups with *Sc. Lloydii* and *Sc. rectus,* resembling them in its smooth ovoid form. *Sc. Knerii* (p. 20), from the Silurian beds of Gallicia, on the other hand, resembles much more closely our own Upper-Silurian species, *Sc. Ludensis* and *Sc. truncatus,* in its angular lateral margins and median ridge.

Fig. 9.



Head-shield of Scaphaspis Knerii.

Fig. 10.



Head-shield of Scaphaspis Dunensis.

1. Scaphaspis Lloydii. (*Agass.*). Pl. I; and Pl. VII, figs. 1, 6, 17, 18.

Cephalaspis Lloydii, } *Agassiz.* Poiss. foss., vol. ii, p. 149, pl. 1*b*, figs. 8—10, 1835.
— Lewisii, }

Pteraspis Lloydii, *Kner.* Haid. Nat. Abhandl., vol. i, p. 159, pl. 5, 1847.

Scaphaspis — *Lankester.* Brit. Assoc. Rep. Trans. Sect., p. 58, 1864.

Derivation.—Named after Mr. Lloyd, of Whitbach.

Characters.—Scutum ovatum, parte anteriore latiore quam parte posteriore; postice sub-acute terminatum, antice margine lato, curvato; lateribus aliquanto depressis et inflectis; superficie externâ striis regulariter ornatâ præter superficiem marginis anterioris striis paucis eccentricis notatam; superficie internâ lævi, duobus colliculis obliquis antice, et rugis lateralibus notatâ.

Stratigraphical Position.—Lower Old Red Sandstone (Cornstones).

History.—This is one of the species determined by Professor Agassiz. One of the type specimens figured by the distinguished Ichthyologist is a very good representative of the form (Pl. I, fig. 5); the other (fig. 10) is a broken, distorted specimen: neither of them show the surface-markings or substance of the shield. The specimen drawn in fig. 9, which is a young and somewhat flattened example of this species, was described by Professor Agassiz as *Cephalaspis Lewisii*, the specific name being in honour of Mr. Lewis, of Ludlow. I have no doubt that the specimen figured belongs to the species *Sc. Lloydii.* It is quite possible that Professor Agassiz may have meant to include some other form with that he figured under the name *C. Lewisii*, but there is nothing in the text of his work which tends in any way to explain his views more clearly. The specific name "Lewisii" is a synonym of *Lloydii*, and has been applied by the local and other geologists to a distinct form of *Scaphaspis*, which must henceforth receive a new name.

General Remarks.—*Scaphaspis Lloydii* is one of the commonest species in the Cornstones of Herefordshire and Worcestershire, and is generally obtained in a better state of preservation as regards its form than others of the section. It is, however, rare to obtain a specimen showing the surface of the shield at all satisfactorily. The largest specimens I have seen measure from three to three inches and a half in length, and one and three quarters of an inch in breadth at the broadest part of the shield, which is about the middle. Specimens of from two to two inches and a half in length are more common, but are usually more crushed and imperfect than the larger ones. The outline of the scute presents a most striking similarity to that of a perfect "Cuttle-bone" of the common *Sepia officinalis.* The form is that of a true ovoid, with the broader curvature in front; the egg-like outline is, however, slightly modified by a depression of the sides of the shield along the narrower portion of the ovoid, which appears as though flattened out and slightly produced along its posterior lateral margins. This, I believe, is caused by the growth of the shield, since it is not nearly so apparent in small as in large specimens. An examination of the internal casts, some beautiful specimens of which are figured in the Plate, shows a few well-marked, broad furrows, corresponding to fainter depressions on the surface of the scute, which mark out regions of differing convexity on that surface. These lines appear to be caused by variations in the process of calcification of the shield by the thickening of its margin, and subsequent regular increase; somewhat in the same way as ridges are produced in the shells of Brachiopoda and Lamellibranchiate Molluscs, if it is allowable to compare so dissimilar structures. They distinctly trace out

the form of the shield when of smaller size, the portion within the oval furrows being more convex than that which is outside and nearer the margin. In addition to these large concentric impressions, there are two furrows to be observed on all casts of this species, also indicated by depressions of the surface of the test, which run from the slightly undulated anterior margin towards a point in the median line, varying from one sixth to one third of the length of the scute from that margin. These lines indicate the 'rostral region,' since they mark off the anterior portion of the scute, which may be considered homologous with the rostrum in *Pteraspis.* Similarly the elliptic furrows mark off the portion corresponding to the lateral coruna. In large specimens the oblique ridges are of much greater length than in the smaller ones, which is owing to the fact that the whole anterior portion of the shield grows more rapidly than the posterior: this is most obvious from an examination of such specimens as figs. 2 and 7, in which it is clearly indicated by the lines of growth that slight addition only is made to the posterior part of the shield, the whole tendency of its development being in an anterior direction. A small notch or inward curvature of the anterior margin, observable in some casts in this species, appears to be due to the thickening of the test, which is somewhat produced at this point.

It is hardly possible to describe the arrangement of the concentric striations on the surface of the test, and indeed it is not necessary, as the artist has taken great pains to render them faithfully in the drawings of the specimens submitted to him. A series of small pits, arranged in pairs and diverging from the centre of the scute, mark the position of muciparous glands, and are seen in figs. 4 and 8.

The form of the minute ridges between each consecutive pair of striations appears to be characteristic of the species of *Heterostraci.* In *Scaphaspis Lloydii* the striæ are $\frac{1}{80}$th of an inch apart near the centre of the shield; at the sides they appear as though compressed, and are only $\frac{1}{200}$th of an inch apart; the ridge left between has a *flat,* glittering surface, and is obscurely serrated within the groove. Fragments of this species may be readily distinguished from *Pteraspis rostratus,* with which it is often associated, since in the latter the intervening ridges are much narrower, rounded, and have a dull surface.

Localities.—In addition to the numerous quarries in the Lower Old Red of Herefordshire, Worcestershire, and Shropshire, which have furnished abundance of specimens of *Scaphaspis Lloydii,* Mr. Powrie has submitted to me specimens from Forfarshire (obtained by the Rev. Hugh Mitchell, of Craig, near Montrose), which, though very fragmentary, preserve sufficient character to warrant the conclusion that they belong to this or a closely allied species. Agassiz states that he obtained this species from all localities in England where *Cephalaspis Lyellii* occurred.

2. Scaphaspis rectus, *Lankester*. Pl. II, figs. 5—8, 12, 13 (figs. 6 and 8 are drawn upside down); and Pl. VII, fig. 2.

Syn. Pteraspis Lewisii, of Collectors, not of *Agassiz*.

Derivation.—*Rectus* (straight), from the straight equal form of the shield.

Characters.—Scutum cephalicum oblongum antice nec postice paulatim attenuatum; postice decussatum et in medio indentatum, marginibus lateralibus rectis, parallelis, superficie externâ striis concentricis parallelis ornatâ, superficie internâ colliculis obliquis marginalibus notatâ.

Stratigraphical Position.—Lower Old Red Sandstone (Cornstones).

History.—By some means or other the specific name *Lewisii* has been connected with this species, although it is not the *Cephalaspis Lewisii* of Prof. Agassiz. The reason of this is probably that geologists finding two forms of *Scaphaspis*, closely allied, and knowing that Agassiz had distinguished two such allied species, concluded that one of those found by them must be his *C. Lloydii*, the other his *C. Lewisii*. This conclusion, however, is wrong, and I have accordingly renamed this species.

General Remarks.—This is a much smaller species than the last, and is much less widely distributed, though abundant in some quarries. The largest specimens measure about two inches and a half in length.

Scaphaspis rectus is characterised by the great narrowness and convexity of the scute, and by the fact that its sides are in a great measure parallel, so that it does not present the broad ovoid which we have in *Sc. Lloydii*, but a narrow, oblong, semicylindrical body. Anteriorly, the margins of the shield converge, not, however, in a sweeping curve as in the last species, but somewhat obliquely, leaving a small horizontal frontal margin. A more decided differentiating character (not always preserved) is the presence (in casts) of a very obvious notch or excavation in the median line at the posterior margin of the shield, this margin otherwise being more nearly horizontal than in *Sc. Lloydii*, and presenting the appearance of being truncated, instead of being produced to a subacute termination. These characters are quite sufficient to distinguish *Sc. rectus* from *Sc. Lloydii*, with which it is likely to be confounded. I have, however, often had great difficulty in determining fragmentary specimens. With regard to the markings on the inner and outer surface of the test there is little to be said. Those on the inner surface differ very little from the similar furrows in *Sc. Lloydii*, being, however, less marked. There is a slight excess of growth in an anterior direction, but far less exuberant than in the allied species. It is from this cause that the lateral margins[1] of the shield remain parallel. The two converging furrows arising from the frontal margin are traceable in casts of this species, as

[1] The furrows on these margins indicate ridges in the test itself. It has to be borne well in mind that the internal casts, by which most *Cephalaspidæ* are known, only partially indicate the characters of the

well as a series of similar furrows arising from the lateral margins (Pl. II, fig. 12). The striations on the external surface follow the outline of the scute, as in *Sc. Lloydii.* They are, on the average, $\frac{1}{200}$th of an inch apart near the centre of the scute, and leave a flat, smooth-surfaced, crenated ridge between them. The striations do not converge posteriorly, since the outline of this part of the shield is not subacute, as in *Sc. Lloydii*, but nearly horizontal; hence the striations following the outline do not meet at a small angle, but terminate at the posterior notch.

Distribution.—This species occurs frequently by itself, and is often absent where other species of Devonian *Heterostraci* abound. It is met with in Worcestershire (Hall's Barn, Aightington), and in Herefordshire frequently. At Whitbach it occurs with *Pteraspis Crouchii.*

3. Scaphaspis truncatus (*Huxley and Salter*). Pl. II, figs. 1—3.

Syn. Pteraspis truncatus, *Huxley* and *Salter.* Quart. Journ. Geol. Soc., vol. xii, p. 100, pl. ii, fig. 1, 1856.

Derivation.—Truncatus (cut off), from the abrupt termination of the front part of the scute.

Characters.—Scutum elongatum, ovatum, convexum, antice truncatum, postice attenuatum et brevispinosum; superficie externâ rugis undosis longitudinalibus, tenuissime interstriatis ornatâ.

Stratigraphical Position.—Downton Sandstone, and Ludlow Bone-bed.

History.—This species was discovered by Mr. Banks, of Kington, and described by Messrs. Huxley and Salter in 1855.

General Remarks.—This and the following species of *Scaphaspis* form a pair much in the same way as the two Devonian species *Sc. Lloydii* and *Sc. rectus* do. Though having the typical form of shield, the Silurian *Scaphaspides* differ from the Devonian very obviously in their surface-striations, and in the presence of a median ridge, which runs longitudinally at the posterior part of the shield.

Sc. truncatus is quite a small species rarely exceeding an inch and three quarters in length. A slightly elevated ridge on the median line, running from nearly the centre of the scute, terminates posteriorly in a very short spine or tubercle. The general outline of the scute is that of a well marked ovoid, truncated, and slightly emarginated in front, and acutely terminated behind. The markings of the surface are very characteristic, and, at the same time, are retained in very few specimens that I have seen, most of which are indifferent examples of the internal cast. From twenty to thirty undulating ridges

shield; and this, perhaps, may prove a source of error in some cases in the view taken of the forms of the various shields.

extend in a longitudinal direction from near the frontal margin, and converge towards the spinous termination of the ovoid scute; these are interstriated by the fine grooves characteristic of all *Heterostraci.* The space in front of the origins of the longitudinal ridges is transversely striated and somewhat thickened, indicating the rostral region, as in other Scaphaspids.

Distribution.—The only locality at present known for this species in the Downton Sandstone is Kington, Herefordshire. I have seen a fragment in a slab from the Ludlow Bone-bed.

4. Scaphaspis Ludensis (*Salter*). Pl. II, figs. 4, 4 *a*.

Syn. Pteraspis Ludensis, *Salter.* Annals and Mag. Nat. Hist., 3 ser., vol. iv, p. 45, woodcut, fig. 1, 1859.

Derivation.—*Ludensis,* belonging to Ludlow.

Characters.—Scutum elongatum, oblongum, ovato-quadrangulare, antice et postice truncatum, postice spinâ brevissimâ armatum; superficie externâ colliculis longitudinalibus rectis antice transversis, non interstriatis ornatâ.

Stratigraphical Position.—This species has been found in both the Lower and the Upper Ludlow beds.

History.—Mr. Salter, in 1859, described this fish-shield from specimens obtained by Mr. Lee and Mr. Robert Lightbody, of Ludlow.

General Remarks.—This, the oldest vertebrate animal of which traces have been met with, is known by but a very few imperfect specimens. It was first obtained from the Upper Ludlow deposits, but was afterwards detected near Leintwardine, in Shropshire, by Mr. Lee, in the Lower series bearing that name; this discovery added enormously to the age of the fossil.

The form of the scute in *Scaphaspis Ludensis* is that of a much elongated ellipse truncated at both ends, the small spinous tubercle situated near the posterior margin of the shield hardly projecting beyond it. Like that of *Sc. truncatus,* the spine is the termination of a lightly marked central ridge; and, as in that species, the inner surface of the shield exhibits indications of this ridge and of the coarse longitudinal furrowing of the outer surface. As *Sc. rectus* resembles *Sc. Lloydii* in many points, but differs in being much narrower, and in not terminating acutely behind, so does *Sc. Ludensis* resemble and differ from *Sc. truncatus.* The ornamentation on the outer surface of the shield is in the form of straight longitudinal ridges and furrows, coarser than in other *Heterostraci.* These ridges do not converge, but run parallel from one end of the shield to the other, a small frontal portion being left which is transversely marked. The length of the largest scute I have seen is about one inch and a half.

Localities.—The neighbourhood of Ludlow; and Church Hill, Leintwardine.

Genus 2.—CYATHASPIS, *Lankester*. Brit. Assoc. Rep., Trans. Sect., p. 58, 1864.

Syn. PTERASPIS (BANKSII), *Huxley* and *Salter*. Quart. Journ. Geol. Soc., vol. xii, p. 100, 1856.

Derivation.—κύαθος, a spoon ; ἀσπίς, a shield.

Characters.—Scutum cephalicum ovale, aliquanto elongatum, postice truncatum et brevi-spinosum; in quatuor partes divisum,—*rostrum* breve anterius,—*cornua duo* lateralia, marginibus scuti admodum depressis formata,—centralem discum. Superficie striis et liris longitudinalibus, in rostro transversis, ornatâ.

General Remarks.—The evidence on which this genus is formed is more scanty than that on which the foregoing and the following genus rest. At the same time, it appears impossible to associate *Pteraspis* (*Cyathaspis*) *Banksii* of the Downton Sandstone with either the simple oval-shielded *Scaphaspis* or the more elaborate *Pteraspis*. The specimens that I have examined are not very good or satisfactory examples, though they are, I believe, the best yet discovered; and from them it appears that in these shields the anterior portion is marked off as a distinct rostrum, projecting beyond the rest of the oval scute; the sides are much depressed, and also marked off from the rest of the scute, the demarcated pieces extending on each side to the rostrum, from which they are similarly separated. This "marking off" is effected by a break in the parallel striations of the upper surface, by a linear groove emarginating each portion, and by dissimilarity in convexity and curvature of the marked-off segments. These pieces had in all probability each a distinct development and growth, as in *Pteraspis*. The lateral pieces correspond to the lateral cornua of that genus; the spine and orbital parts are not distinct pieces; the former being but a spinous tubercle on the disc when it occurs, and the latter in all probability are connected with the rostrum. Some casts of *Cyathaspis* shields show a marginal tubercle on either side the rostrum, corresponding with similar tubercles in *Pteraspis* casts, which are produced by the supposed orbital aperture. I have not had specimens which show the shield itself of *Cyathaspis* sufficiently well to demonstrate the nature of these tubercles in the casts, but it seems probable that they are connected with the orbits. The species belonging to this genus, concerning which more information would be most welcome, are two in number at present; one is known by a score or so of poor specimens from the Downton Sandstone of Kington, the other by a single fine internal cast from the Cornstones of Herefordshire.

1. CYATHASPIS BANKSII (*Huxley and Salter*). Pl. II, figs. 9, 10, 11; and Pl. IV, fig. 6.

Syn. PTERASPIS BANKSII, *Huxley* and *Salter*. Quart. Journ. Geol. Soc., vol. xii, p. 100, pl. ii, fig. 2, 1856.

Derivation.—Named after its discoverer, Mr. Banks, of Kington.

Characters.—Scutum ovale: *discus* centralis convexus postice truncatus et spinâ brevissimâ, striis longitudinalibus minutis externe ornatus: *rostrum* breve, rotundatum, striis transversis ornatum: *cornua* cum disco usque ad truncationem juncta, externe striis longitudinalibus ornata.

Stratigraphical Position.—This fossil has at present been found only in the Downton Sandstone.

History.—Mr. Salter, in conjunction with Prof. Huxley, described this species as *Pteraspis Banksii*, from specimens found by Mr. Banks at Kington in 1859.

General Remarks.—There is little to be said of this species beyond what has been said in the description of the genus. The rostrum projects a little beyond the rest of the scute, and is rounded off in a gentle curve; the lateral cornua embrace the central oblong convex disc throughout its length, terminating abruptly with it in the posterior region, which has the aspect of being sharply truncated. A little above the truncation of the scute in the median line is the origin of a short spine or projection. I have seen nothing in the specimens I have examined of the "costuli" and double series of ten "tubercles" mentioned in Messrs. Huxley and Salter's description, which I cannot but think is erroneous in this respect. On either side of the rostrum in casts is a marginal tubercle, probably connected with the orbit, but specimens sufficiently well preserved to make this clear have not been found. The surface is very finely striated, and the convexity of the central portion of the shield in uncrushed examples very great. The length of the scute of this species is from an inch and a half to an inch and three quarters; its breadth from a little over an inch to an inch and a half.

Locality.—Kington, Herefordshire.

2. Cyathaspis (?) Symondsi, *Lankester.* Pl. VI, fig. 5.

Cyathaspis (?) Symondsi, *Lankester.* Brit. Assoc. Rep., Trans. Sect., p. 58, 1864.

It is useless to give any definite character to this species at present, as it rests on a single specimen, which, though indicating a remarkable Fish belonging apparently to this genus, is too imperfect to warrant any further affirmation in regard to it.

This specimen has been for some time in the Collection of the Geological Survey, and is labelled as coming from the Cornstones, Herefordshire; it is a well-preserved smooth-surfaced cast of the interior of the scute, and measures three inches and a half in length, and two and a half in breadth, being one of the largest *Heterostraci* known. Its form is rather rectangular than ovoid. The central and median portion is convex and raised up above the rest of the scute; it projects backwards, some little way from the flatter portion, and has a rounded truncated posterior margin. In front the flat portion is produced into a small rostrum which has an incurved frontal

margin, the flat portions at the sides form the lateral cornua, and terminated abruptly with a rounded horizontal margin, leaving the central convex portion to pass backwards unembraced, for the length of about half an inch.

A comparison of this cast with those of *Cy. Banksii* shows considerable similarity in the parts of the two scutes.

I have named it after the Rev. W. S. Symonds, of Pendock, Worcestershire, who is one of the most energetic investigators of the Old Red strata of that district.

Genus 3.—Pteraspis.

Syn. Pteraspis (*Kner*), *Huxley.* Quart. Journ. Geol. Soc., vol. xii, p. 100, 1856.
— *Lankester.* Brit. Assoc. Rep. Trans. Sect., p. 58, 1864.

Derivation.—πτερόν a wing, ἀσπίς a shield; either from the sculptured surface of the shield (?) or from its supposed wing-like cornua.

Characters.—Scutum cephalicum sagittiforme; in septem partes divisum,—*rostrum* conicum elongatum anterius,—*spinam* longam posteriorem,—*discum* magnum centralem, quadrangularem vel ovatum rostro junctum,—*duas partes orbitales,* rostro et disco utrinque junctas,—*duo cornua lateralia* quicque fossâ tubulari perforatum, utrinque disco et parti orbitali juncta; superficies externa in partibus variis diverse striis minutis parallelis ornata; superficies interna lævis, colliculis paucis et fossis notata.

General Remarks.—In this genus the *Heterostraci* attain the most composite form of scute. Seven distinct portions are marked off as well by ridges on the lower surface of the shield as by furrows, and by the arrangement of the striæ on the external surface. The form of the shield is no longer merely oval, or a modified ovoid, but the diverging appendages become so far developed before, behind, and laterally that the outline somewhat resembles what botanists term a *sagittate* leaf, though this does not express the form accurately. The head-shield of *Pteraspis* presents a recognisably piscine appearance, and the orbital apertures with the long snout and projecting perforated "cornua" prevent the possibility of its true character being overlooked. The shield is composed of seven pieces instead of four as in *Cyathaspis:* a long conical rostrum; a large more or less oval central disc, into which is fitted a large posterior spine; an orbital piece on each side attached to the rostrum and disc; and a lateral cornu on each side attached to the disc and orbital piece, from which it is scarcely distinct. In the median line, where the rostrum joins the disc, is a minute, round depression, with circular striations, perhaps forming an eighth, though very diminutive, piece. The distinctness of these pieces has been already spoken of (pages 17 and 18). The facts bearing on the matter, as far as this genus is concerned, are the following: each of the seven parts has its own series of striations, arranged transversely on the rostrum, circularly around the orbital aperture

on the orbital portions, longitudinally on the lateral cornua, concentrically around a central point on the disc, longitudinally on the spine: none of these series of striations run into or form part of another series; each piece is marked off from its adjacent piece by a slight groove on the upper surface, and by a thickened ridge below: the striæ are of the same size in young as in old specimens: in young specimens it is not unusual for the rostrum, spine, and orbital portions to be separate from the disc (particularly in the longirostrate species): the *proportionate* size of the various pieces of the shield is the same in large as in small specimens. From these facts the inferences are: 1st, that the growth of the scute was not simple,—that is, it did not proceed merely along the margin of the shield as from one centre; 2nd, that the number of concentric or parallel striæ must have been increased on each portion as the scute advanced in size; 3rd, that this increase in size must have taken place around or along the margin of each piece. Hence, it appears that each portion had a separate growth; and when quite young the pieces were very possibly (so far as their calcareous substance is concerned) quite distinct; they united as they advanced in size, and became firmly joined when fully developed by the thickening and fusing of their adjacent margins.

The inner surface of the shield in *Pteraspis* is smooth and shining; for about half its length, however, on the under surface, the rostrum is striated as on its upper surface; it is then suddenly excavated, and the hollow of the shield commences, with which the soft parts of the Fish were connected. The inflected thickened margin of the shield all round is striated, as also the under surface of the bulging cornua and the posterior spine. There are ridges on the inner surface caused by the anchylosis of the different pieces; and there are a very few remarkable ridges radiating from the centre of the disc, varying in the different species. Corresponding to the minute circular piece between the rostrum and disc is a deep pit on the inner surface, which occurs in the species of *Pteraspis* most markedly, and appears also to exist in *Cyathaspis* (Pl. II, fig. 11). I can offer no explanation of this pit and the diverging ridges.

The restoration of the shield of the genus *Pteraspis* was first attempted by Professor Huxley ('Quart. Journ. Geol. Soc.,' vol. xvii, p. 165, 1861), who gave an outline of the scute in the commoner species *Pteraspis rostratus.* It has been a matter of very serious difficulty to obtain anything like a satisfactory notion of the form of the "cornua" in this genus, since the abundant casts only mislead, and specimens with the test preserved are hard to get. The figures 8 and 9 in Plate VII represent what I have been able to ascertain by breaking up many specimens. The "cornua" are thick solid bodies, which do not diverge from, but merely project above, the thickened margin of the disc. A large oval orifice opens on each side into the substance of the shield just below the projecting cornu. A short passage, partly perforating the cornu, runs obliquely forward from this orifice, opening widely again into the concavity of the shield, quite at its margin, and within the area of its posterior half. Perhaps this pair of holes were connected with the branchial apparatus. The Rev. Hugh Mitchell, of Craig, was the first to point out

their existence. Professor Agassiz curiously misunderstood the nature of the scute in his *Ceph. rostratus,* for he was able in the specimen figured in Pl. IV, fig. 2, to find two large dorsally placed orbits similar to those of *Cephalaspis Lyellii ;* it is obvious enough that these do not exist, while it is equally difficult to recognise the "ethmoid" spoken of by him, as well in *rostratus* as in his *Lloydii* and *Lewisii.*

The genus *Pteraspis* includes three species, limited to the Lower Old Red Sandstone, two occurring in the Cornstones of the West of England, the other obtained in Forfarshire. I have had specimens from Herefordshire, which may indicate other species; they are not sufficiently satisfactory to warrant further notice.

1. Pteraspis Crouchii, *Salter.* Pl. III; Pl. IV, fig. 5; Pl. VI, figs. 4, 7, 8; and Pl. VII, figs. 4, 8, 11.

Pteraspis Crouchii, *Salter*, MS.
— — *Lankester.* Brit. Assoc. Rep., Trans. Sect., p. 58, 1864.

Derivation.—Named after the Rev. J. F. Crouch, of Pembridge.

Characters.—Scutum antice et postice attenuatum: *rostrum* longum et attenuatum; *discus* elongato-cordiformis, apice utrinque oblique truncato: *spina* longa: *cornua lateralia* magna, crassa: superficies superior rostri parsque inferioris striis curvatis parallelis ornatæ, superficies externa disci et partium orbitalium striis concentricis ornata.

Stratigraphical Position.—Lower Old Red Sandstone (Cornstones).

History.—Specimens of this species in the Ludlow Museum have been named *Pt. Crouchii* by Mr. Salter; and this name I have adopted. This species was not known to Prof. Agassiz.

General Remarks.—This form of *Pteraspis* is distinguished by its long attenuated rostrum, and by the casts of its disc being shaped like an elongated "heart" truncated obliquely on each side of the apex, and having a broad, deeply undulate anterior margin. The rostra are frequently found detached from the rest of the shield, and I have seen no specimen in which they themselves were attached to it: many specimens, however, show the cast of the concave part of the rostrum, in conjunction with that of the orbital portions and disc (the substance of the rostrum itself having in all probability broken away in the stone, on account of the upward curve which it makes). One specimen belonging to Mr. Humphry Salwey, of Ludlow, shows the striations and contour of the elongated rostrum in connection with the cordiform shield; the specimen is the largest I have seen, and it is probably owing to its mature age that the connection between rostrum and disc was sufficiently strong to persist. It is from this specimen chiefly that the pointed long rostra have been shown to belong to the cordiform discs. The part of the rostrum, about half its whole length, which is striated both above and below, is thick and solid, and presents a considerable development of the layer of polygonal cavities within. Its

sides in this part are nearly parallel, converging slightly towards the anterior rounded termination. Where the rostrum becomes excavated, convex and smooth beneath, it broadens very much, and joins on either side the orbital pieces, and in the centre the disc and circular piece. Most casts show well the existence of a sharply marked pit corresponding to this circular bit. The posterior spine in this species is long and strong, its insertion extending into the disc for a distance of about one half of its own length, and one third of that of the disc. The test of the posterior part of the shield is very thick, and gives the perfect shield an outline somewhat different to that of the convex internal cast.

The cornua appear to be thick processes, overlying the oblique penetration of the shield, as in those of the succeeding species.

The markings of the internal surface of the disc in most cases afford means of determining otherwise doubtful specimens of *Pt. Crouchii*. The median line, after the insertion of the spine, is marked by a sharp depression, which becomes fainter towards the anterior portion. On either side of this diverges, from near the centre of the disc, an irregularly marked straight ridge, passing anteriorly in an oblique direction; sometimes these are not perceptible as ridges. Below these straight ridges on either side are two curved ridges, the lower pair of which pass from the centre nearly right and left, the upper pair (nearest the straight ridges) curving obliquely towards the anterior margin. In the casts of the interior, which so frequently occur, these ridges are, of course, exhibited as furrows, and the median groove as a ridge. Similar ridges exist in *Pt. rostratus*, but are not usually so well marked.

The surface-striations of the shield are exhibited in the drawings. Those on the rostrum are semi-elliptical in direction, the open part of the ellipse being turned anteriorly on the upper, posteriorly on the under surface.

The groovings are $\frac{1}{120}$th of an inch apart (average), leaving a flat, bright, crenate ridge between them.

Localities.—*Pteraspis Crouchii* has been obtained from Whitbach and Ludlow. The greatest number of specimens now occur in that neighbourhood. It is also met with at Abergavenny. I have never heard of specimens of this species occurring in immediate association with *Pt. rostratus;* and I believe it has a different horizon. *Scaphaspis rectus* occurs with it and the *Cephalaspis asterolepis* of Dr. Harley.

Note.—The scales of *Pteraspis* (Pl. V, figs. 3, 5, 8) which I obtained at Cradley, Herefordshire, perhaps belong to this species.

2. Pteraspis rostratus, *Agassiz*. Pl. IV, figs. 1, 2, 3, 7, 8; Pl. V, fig. 4; Pl. VI, figs. 1, 2, 3, 6, 10; and Pl. VII, figs. 3, 5, 9, 12, 13, 16, 17, 19.

Cephalaspis rostratus, *Agassiz*. Poiss. foss., vol. ii, p. 148, pl. i *b*, figs. 5, 6, 1835.
Pteraspis rostratus, *Huxley*. Quart. Journ. Geol. Soc., vol. xvii, p. 165, woodcut, 1860.
— — *Lankester*. Brit. Assoc. Report, Trans. Sect., p. 58, 1864.

Derivation.—Rostratus, bearing a rostrum.

Characters.—Scutum grandius et minus attenuatum quam in *Pt. Crouchii; rostrum* cuneiforme, *discus* elongatus, quadrangularis lateribus parallelis, *spina* magna, *cornua lateralia* angularia; rostri superficies superior striis undosis, antice curvatis, parallelis ornata; superficies externa disci et partium orbitalium striis concentricis ornata.

Stratigraphical Position.—Lower Old Red Sandstone (Cornstones).

History.—This species is more common than the last, and appears to be the one which was known to Prof. Agassiz. Prof. Huxley gave a restoration of its outline[1] in 1860. Agassiz's type specimen is drawn in Pl. IV, fig. 2.

General Remarks.—This is a larger species than *Pt. Crouchii*, sometimes attaining a length of four inches and a half from the tip of the rostrum to the termination of the disc. It differs from *Pt. Crouchii* in the shape of its rostrum, which is broader at its termination and shorter relatively than in that species,—in the shape of its disc, which is that of a parallelogram with the anterior angles rounded off,—in the shape of its cornua, which are thicker and stronger in *Pt. Crouchii*,—in the relative length of its spine, which is less deeply inserted in the disc. It is by no means uncommon to get specimens of this species with all the parts adherent. The rostrum does not readily break off as in *Pt. Crouchii;* and, not being proportionately so large nor upwardly curved, it is more frequently preserved, and knocked out of the stone with the rest of the shield; indeed, it is rare to see a specimen of *Pt. rostratus* in which all the parts are not attached, though still rarer to see one in which they are not to a large extent inextricably imbedded in the dense Cornstone. The markings of the inner surface of the disc consist of two straight ridges on each side passing obliquely forwards from the region of two small oblong depressions situated on either side of the median line, a little posterior to the centre of the shield, and of a broad anterior elevation in the median line, corresponding with a similarly broad depression of the outer surface. Two curved lines, similar to those in *Pt. Crouchii* are noticeable in some specimens; but they are not so constant or so sharply marked as in that species. The striations on the outer surface are

[1] The very obscure cornua were not quite correct in this outline (nor in that which I gave in the 'Quart. Journ. Geol. Soc.,' vol. xx, p. 194, pl. xii, fig. 10); but in all other respects the restoration was most valuable.

disposed concentrically round a middle point, as in *Pt. Crouchii*, but this portion of the shield is apparently elevated into a slightly convex boss. The surface-striations of *Pt. rostratus* differ considerably from those of *Pt. Crouchii*. They are very fine, the groovings being only $\frac{1}{200}$th of an inch apart near the centre of the disc, and leaving a rounded dull ridge with crenate margins between them.

Localities.—This species occurs abundantly at Cradley, near Malvern, Herefordshire, and in beds of the same horizon at Whitbach and in the neighbourhood. It is found associated with *Scaphaspis Lloydii*.

3. PTERASPIS MITCHELLI, *Powrie*. Pl. V, figs. 1, 2, 6, 10, 11.

PTERASPIS MITCHELLI, *Powrie*. Geologist, vol. vii, pp. 170—172, 1864.
— — *Lankester*. Brit. Assoc. Report, Trans. Sect., p. 58, 1864.

I have not had specimens of this species sufficiently perfect to enable me to characterise it properly. The specimen figured (Pl. V, figs. 6, 10) was briefly noted by Mr. Powrie in the 'Geologist,' in 1864, and an outline-sketch was given. The lateral cornua are not seen, but the disc, rostrum, and spine are, to a certain extent. The disc appears to be intermediate in form between that of *Pt. rostratus* and *Pt. Crouchii*. The specimen and others even less well preserved were obtained by Mr. Powrie from quarries in Forfarshire, where *Heterostraci* had been discovered for the first time in Scotland by the Rev. Hugh Mitchell.

A few rhomboidal scales also obtained by Mr. Powrie from this locality (Pl. V, fig. 1) probably belong to this or an allied species.

PLATE I.

Fig.

1. *Scaphaspis Lloydii*, showing a portion of the test. Cornstones, Herefordshire. In the collection of the late Mr. Wyatt-Edgell.

2. A well-preserved internal cast, showing the lines of growth and anterior convergent ridges; from Shropshire. In the collection of the late Mr. Wyatt-Edgell.

3. Internal cast; from Cradley, Herefordshire. In the author's cabinet.

4. A specimen showing a large portion of the test; from Herefordshire. In the collection of the late Mr. Wyatt-Edgell.

4 *a*. Anterior portion of the same, enlarged three diameters, to show the irregular striation of the anterior margin and mucous-gland-pits.

4 *b*. Ornamentation of the surface, to show the crenation of the ridges.

5. A fine internal cast. Herefordshire. In the collection of the Rev. J. Crouch.

6. An internal cast; from Cradley, Herefordshire. In the author's cabinet.

7. A large internal cast; from Herefordshire. In the collection of the Rev. J. Crouch.

    b points to the lateral emargination, representing the cornua.

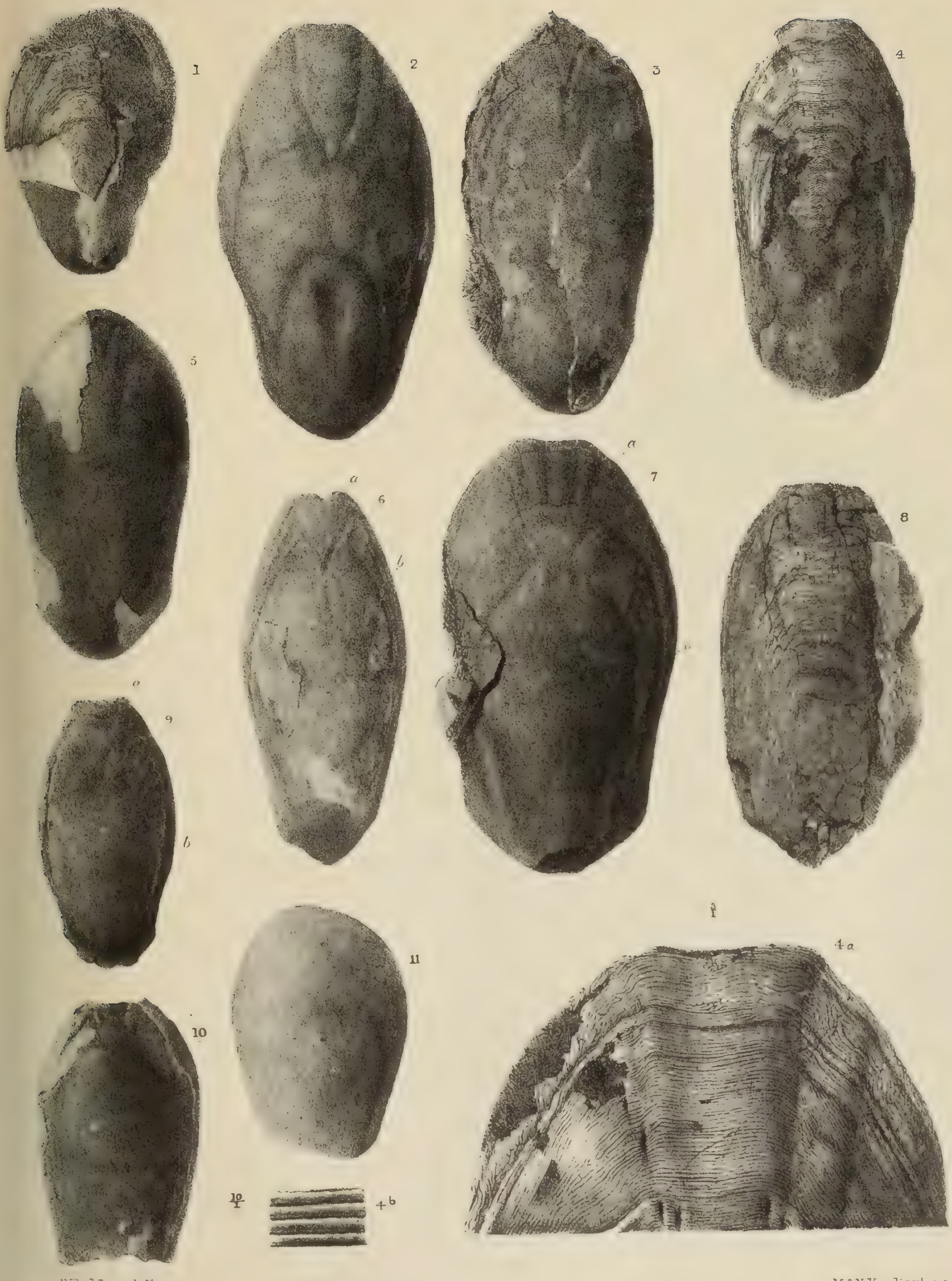
    a to the rostral region.

8. A specimen showing nearly the entire surface of the test; from Herefordshire. In the collection of Mr. Lightbody, of Ludlow.

9. A small example of *Sc. Lloydii*. Agassiz's type specimen of *Cephalaspis Lewisii*, figured 'Poiss. foss.,' Tab. 1 *b*, fig. 8

10. One of Agassiz's type specimens of *Cephalaspis Lloydii*, figured 'Poiss. foss.,' Tab. 1 *b*, fig. 10.

11. A much crushed and indistinct cast of *Sc. Lloydii*. Cradley. In the author's cabinet.



F. Fielding del.t

M & N Hanhart imp

SCAPHASPIS LLOYDII

PLATE II.

FIG.

1. *Scaphaspis truncatus*, an internal cast. Kington, Herefordshire. In the Museum of Practical Geology.

1 *a*. Side view of the same specimen.

2. *Sc. truncatus*, internal cast. M. P. G.

3. ,, ,, a beautifully preserved specimen, showing the sculpturing of the surface. M. P. G.

4. *Sc. Ludensis*, from the Lower Ludlow beds of Church Hill. In the Museum of Practical Geology.

4 *a*. *Sc. Ludensis* (concave surface); from the Upper Ludlow beds, near Ludlow. Mr. Lightbody.

5. *Sc. rectus*, a fragment, showing the surface markings. Shropshire. Mr. Wyatt-Edgell.

6. A concave cast (figured upside down) of *Sc. rectus*; from the Cornstones, Worcestershire. In the author's cabinet. Observe the posterior notch.

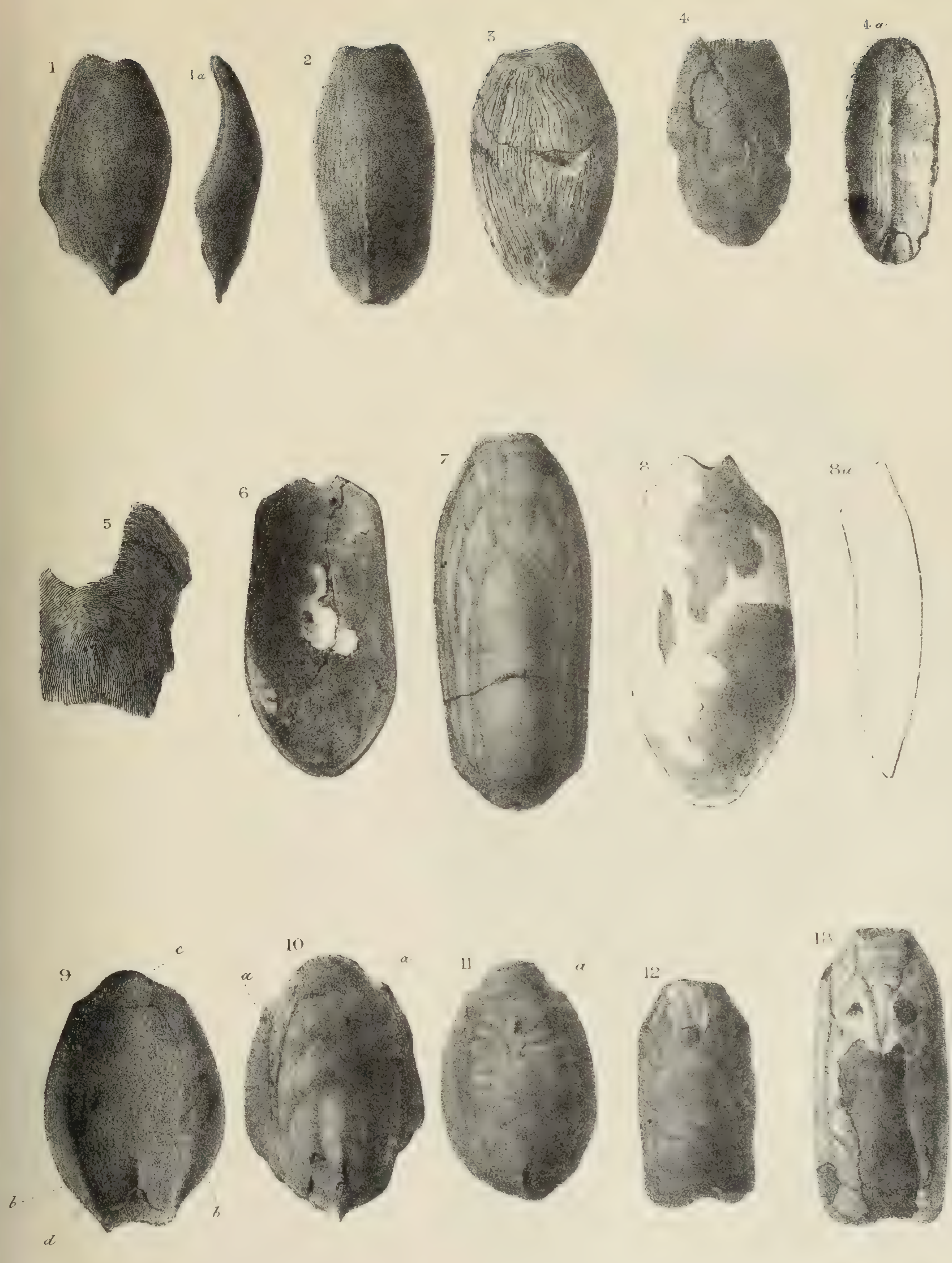
7. A very fine convex cast of *Sc. rectus*; from Worcestershire. In the British Museum.

8. *Sc. rectus*; from a sketch made for Professor Huxley.

9. *Cyathaspis Banksii*, concave cast, showing the surface-striations; from the Downton Sandstones, Kington, Herefordshire. M. P. G. *b*, Lateral cornua; *c*, rostrum; *d*, central disc.

10. } 11. } Convex casts of *C. Banksii*; from Kington, Herefordshire. In Mr. Banks' collection. *a*, Orbital ? tubercles.

12. } 13. } Convex casts of *Sc. rectus*; from Hall's Barn, Worcestershire. In the author's cabinet.



E. Fielding Del.

F. Waller, Imp. 18, Hatton Garden

SCAPHASPIS & CYATHASPIS

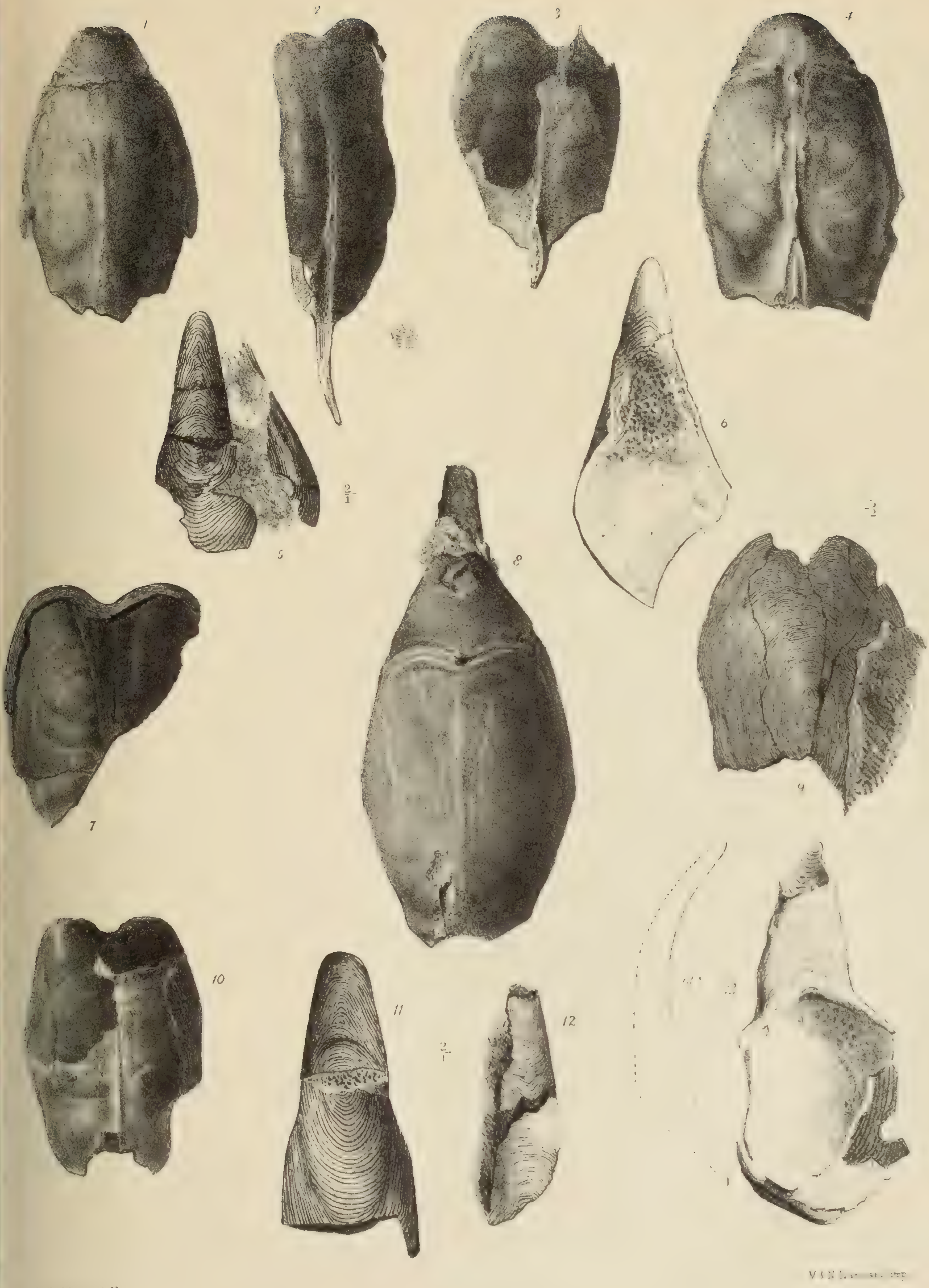
PLATE III.

FIG.

1. An internal cast of *Pteraspis Crouchii,* showing the form of the concave part of the anterior rostrum. Herefordshire. Rev. J. Crouch.
2. A cast (laterally compressed), with the posterior spine attached. It shows well the radiating ridges. Herefordshire.
3. A similar specimen, not compressed. Herefordshire.
4. Cast of Pteraspis shield, probably *Pt. Crouchii,* in yellow sandstone. Shropshire. Mr. Wyatt-Edgell.
5. Rostrum of *Pt. Crouchii,* showing anterior dorsal surface and cast of posterior ventral surface. Rev. J. Crouch.
6. Rostrum of *Pt. Crouchii,* showing anterior under surface. From Mr. Lightbody's cabinet.
7. Portion of disc. Herefordshire.
8. The only specimen showing the tapering rostrum attached to the cordiform disc. Acton Beachamp, Herefordshire. Mr. Humphrey Salwey.
9. Portion of disc, with surface-striations preserved. Herefordshire. Mr. Wyatt-Edgell.
10. An unusually well-marked cast of the disc. Herefordshire. M. P. G.
11. Rostrum. Herefordshire. Dr. Grindrod.
12. Part of rostrum in cast.
13. View from below of a specimen of the rostrum, showing its excavated portion. Herefordshire. Mr. Lightbody.

13 *a.* Lateral outline of the same specimen, showing upward flexure.

All the figures are of *Pt. Crouchii.*



E Fielding del[t]

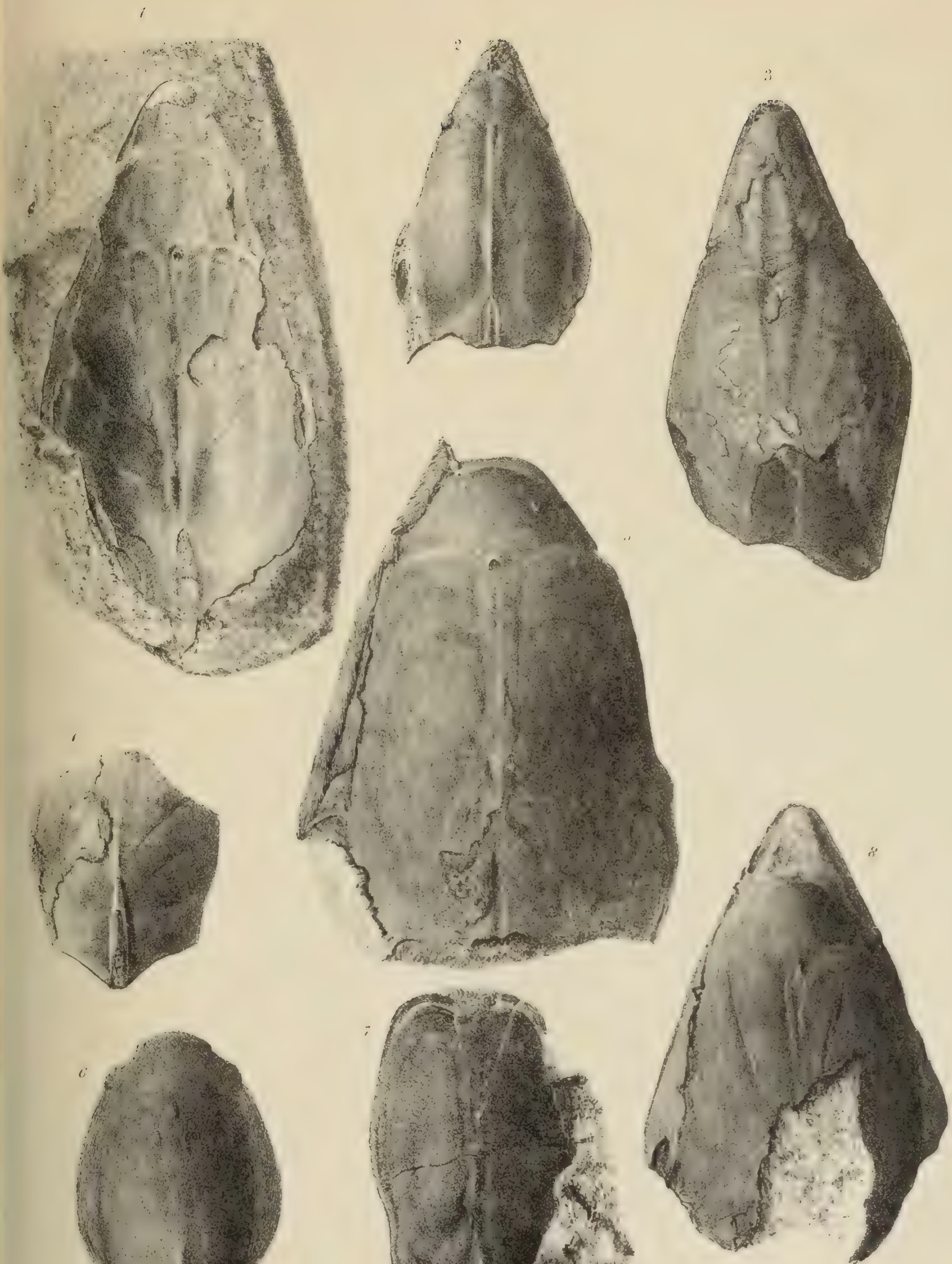
PTERASPIS CROUCHII

PLATE IV.

Fig.

1. *Pteraspis rostratus.* A fine specimen, showing the concave surface of the shield. Observe the pit between rostrum and disc, the elevation into a ridge of the fused margins of these two parts, and the long ridges of the disc. Cradley, Herefordshire. In the author's cabinet.
2. Agassiz's type specimen of *C. rostratus.* The hollow character of the cornua is well seen in the fractured cornu of the left side. Whitbach, Herefordshire. Sir R. I. Murchison. Poiss. Foss. Tab. 1 *a*, fig. 6.
3. *Pt. rostratus.* A specimen showing well the form of the rostrum, and its relation to the anterior margin of the disc. Cradley. Author's cabinet.
4. A portion of the disc of *Pt. Crouchii,* showing the truncated posterior margin and the deep insertion of the spine.
5. One of the largest specimens (an internal cast) of *Pt. rostratus* yet found. Herefordshire. M. P. G.
6. *Cyathaspis Banksii,* a very well-preserved and complete shield. Kington. Mr. Lightbody.
7. Disc of *Pt. rostratus,* with rostrum, cornua, and spine detached. Compare with Pl. III, figs. 3, 8, and 10. Abergavenny. Author's cabinet.
8. *Pt. rostratus,* showing, on the left side, the oval perforation of the cornua.

Pl. IV.



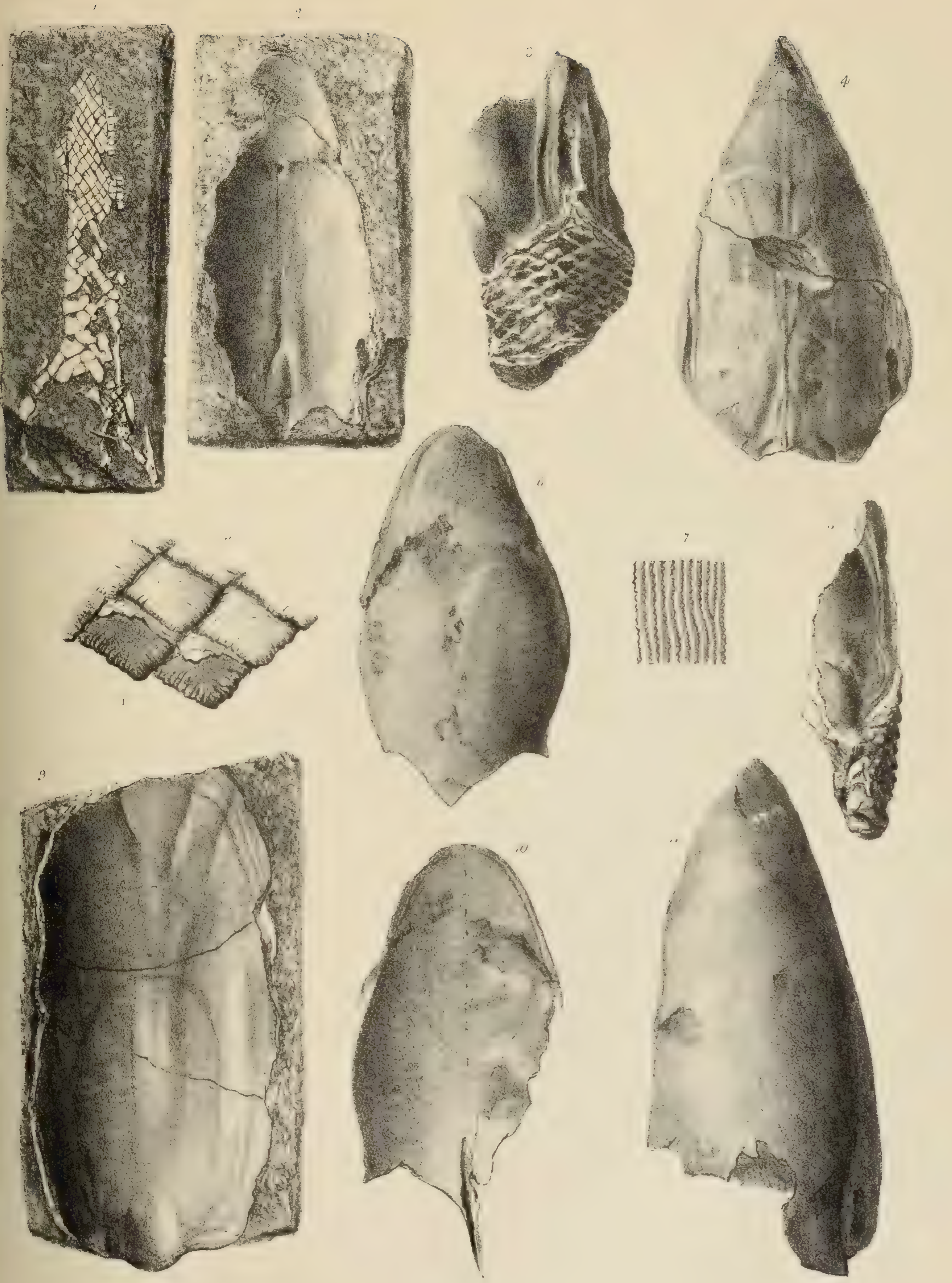
E. Fielding delt. M & N Hanhart imp

PTERASPIS ROSTRATUS *Etc*

PLATE V.

FIG.

1. Scales of *Pteraspis sp.*, Perthshire. Mr. Powrie.
2. *Pteraspis Mitchelli.* View of the concave surface; on the right hand is seen the internal aperture of the cornual perforation. Perthshire. Dundee Museum.
3. Scales of *Pteraspis sp.*, attached to a portion of the striated head-shield (see figs. 7 and 8). Cradley, Herefordshire. Author's cabinet.
4. *Pt. rostratus.* Cast of disc and rostrum, with cornua attached; on the right-hand side the matrix is seen filling the hollow passage of the cornu, and surrounded by bony matter. Cradley. Author's cabinet.
5. Enlarged view of some of the scales of fig. 3, showing surface markings.
6. *Pt. Mitchelli,* a specimen without the cornua and spine. Perthshire. Mr. Powrie.
7. Magnified view of the striations of the part of the head-shield preserved in the specimen drawn in figs. 3 and 8.
8. Side view of the specimen drawn in fig. 3.
9. A huge Heterostracous head-plate, perhaps *Scaphaspis Lloydii.* Near Ludlow. Mr. Humphrey Salwey.
10. The intaglio of fig. 6, showing the spine.
11. *Pt. Mitchelli?* a very large but obscure specimen. Perthshire. Rev. Hugh Mitchell.



E. Fielding del[t]

M & N Hanhart imp

PTERASPIS SCALES Etc

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1867.

LONDON:

MDCCCLXVIII.

THE

BRITISH

PLEISTOCENE MAMMALIA.

BY

W. BOYD DAWKINS, M.A., F.R.S., G.S.,

AND

W. AYSHFORD SANFORD, F.G.S.

PART II.

BRITISH PLEISTOCENE FELIDÆ.

FELIS SPELÆA, Goldfuss.

(Pages 29—124; Plates VI—XIX.)

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1868.

PRINTED BY J. E. ADLARD, BARTHOLOMEW CLOSE, E.C.

MEASUREMENTS.

2nd Phalanges.

Digit 2.	14. Bl. B., Taunton.	*Felis tigris*, Brit. Mus. 114 L.	*Felis leo*, W. A. S.
	Inch.	Inch.	Inch.
1	1·76	1·26	1·38
2	2·00	1·45	1·42
3	0·78	0·68	0·60
4	0·60	0·43	0·50
5	0·78	0·64	0·60
6	0·91	0·50	0·54
Digit 3.	22. Bl. B.		
1	1·80	1·58	1·47
2	1·87	1·31	1·25
3	0·85	0·61	0·68
4	0·58	0·44	0·50
5	0·72	0·62	0·60
6	0·75	0·42	0·50
Digit 4.	15. Bl. B.		
1	1·65	1·50	1·28
2	1·75	1·36	1·31
3	0·83	0·56	0·66
4	0·56	0·43	0·51
5	0·75	0·60	0·54
6	0·69	0·48	0·58
Digit 5.	16. Bl. B.		
1	1·57	1·21	1·20
2	1·75	1·21	1·51
3	0·82	0·59	0·60
4	0·55	0·54	0·50
5	0·72	0·55	0·50
6	0·65	0·45	0·50

Sesamoids; Pl. V, figs. 15, 16.

The sesamoids figured are from Bleadon. They certainly belong to a large carnivore, and are precisely similar to those of a lion in form, though of course much larger in size; and as they are from the Bleadon Cave, where *Felis spelæa* abounds, and bear is extremely scarce, we do not doubt that we are right in ascribing them to the former animal.

CHAPTER VI.

Skull; Pls. VI, VII, VIII, IX, X, XI.

CONTENTS.

§ 1. *Introduction. Skulls of Felis spelæa found in Europe.*
§ 2. *Basi-occipital bone.*
§ 3. *Exoccipital; Supra-occipital.*
§ 4. *Basi-sphenoid.*
§ 5. *Ali-sphenoid; Pterygoid.*
§ 6. *Pre-sphenoid; Orbito-sphenoid.*
§ 7. *Palatine.*
§ 8. *Maxillary.*
§ 9. *Intermaxillary.*
§ 10. *Petrosal; Mastoid; Tympanic; Malleus.*
§ 11. *Squamosal.*
§ 12. *Malar or Jugal.*
§ 13. *Lachrymal.*
§ 14. *Ethmoid.*
§ 15. *Wormian.*
§ 16. *Parietal.*
§ 17. *Frontal.*
§ 18. *Nasal.*
§ 19. *Measurements.*
§ 20. *Summary.*

§ 1. *Introduction. Skulls of Felis spelæa discovered in Europe.*—Perfect skulls of *Felis spelæa* are so very rare that we have had the opportunity of studying no more than three which at all approach completeness—that from Sundwig, in Westphalia, now in the British Museum, of which Professor Owen has given excellent figures in his 'Memoir on Thylacoleo,'[1] and the two which we figure from the Mendip Caves, now in the Taunton Museum. The typical skull figured by Goldfuss, and copied by Cuvier,[2] has altogether eluded our search. It was from the cavern of Gailenreuth from which Lord Enniskillen and Sir Philip de Grey Malpas Egerton have obtained vertebræ and many other bones of Felis, as well as large quantities of the remains of bears.

There are, however, several figures of the skull. M. de Blainville[3] figures a fine and

[1] 'Philosophical Transactions,' 1859, pt. i, pls. xii, xv.

[2] 'Nov. Act. Nat. Cur.,' tom. ix, p. 476, pl. lxv; 'Oss. Foss.,' 1825, 4to, tom. iv, pl. xxxvi, fig. vi.

[3] 'Ostéographie, Felis,' pl. xv.

apparently perfect specimen, which M. Pictet reproduces in his 'Paléontologie.'[1] From the text of the former writer we gather that the figure was taken from a plaster cast in the possession of Count Münster, the original having been found in a cavern in Franconia. D'Alton[2] also figures a perfect or nearly perfect skull from Muggendorf. Other naturalists[3] who have turned their attention to the Pleistocene Fauna describe and figure fragments only of the spelæan skull; for the species, though widely spread through central and western Europe, is nowhere abundant, nor are the remains generally found in a perfect state. The largest English fragment hitherto figured is that found in Kent's Hole Cavern by Mr. McEnery, and drawn on a slightly reduced scale by Mr. Scharf, and published by Mr. Vivian. It is also figured in a woodcut in Professor Owen's 'British Fossil Mammalia.' It represents only a portion of the right maxillary and intermaxillary, with the dentition of an animal of the average size.

Of the two skulls from the caverns of Mendip which we figure, the more perfect and smaller lay for many years after its purchase from the Rev. D. Williams, broken and unseen in a box in the Taunton Museum. The fragments were put together by the present able curator, Mr. Bidgood, and the teeth were afterwards found among a quantity of those of hyæna; and thus a fair specimen of the skull of the British spelæan lion was obtained. Mr. Beard, the explorer of bone-caverns in Somersetshire, on his collection of bones being bought for the Somerset Archæological and Natural History Society, told us of the presence of a skull of a lion from Hutton Cavern, among the bones some time before purchased from his old rival the Rev. D. Williams. As the skull agrees in its condition and colour with the remains from that cave, we have no hesitation in affirming that the original of Pls. VI, VII, VIII, and IX, is the specimen alluded to. When Mr. Beard's collection was brought to Taunton, the small pair of nearly perfect lower jaws figured in Pl. VI was found to correspond exactly with the skull in respect to age, size, and colour. We know that it was the practice of Messrs. Williams and Beard to work at the same cave at the same time, and to share the contents. In this way very frequently a fine specimen was divided between them, even in the case of the long bones,—femora, humeri, and the like. These, now that both collections are in the hands of the Archæological and Natural History Society, are in many cases reunited, and form perfect bones. We have therefore every reason for believing that the lower jaws in Mr. Beard's collection belong

[1] 'Paléontologie,' 4to, 1853—7, pl. vi.

[2] 'Raubthiere,' pl. vii, fig. *a*, *b*, *c*, *d*.

[3] Leibnitz, 'Protogæa,' pl. xi; Buckland, 'Reliquiæ Diluvianæ,' pp. 17, 62, 261; Schmerling, 'Oss. foss. de Liége,' tom. ii, p. 14; Marcel de Serres, Dubreuil et Jean-Jean, 'Oss. foss. de Lunel-Viel,' pp. 101, 107, pl. vii, fig. 1; Rev. W. Vernon, 'Phil. Mag.,' 1829, p. 225; McEnery, 'Cavern Researches,' edit. G. E. Vivian, Esq., 1859; Owen, 'Brit. Foss. Mam.,' p. 161; 'Rep. Brit. Assoc.,' 1842; Falconer, 'Quart. Journ. Geol. Soc. Lond.,' vol. xvi, p. 490; Blackmore, 'Cat. of Fossils in Salisbury Museum,' p. 101; Boyd Dawkins, 'Quart. Journ. Geol. Soc.,' xviii, p. 115; Ed. Lartet, ibid., vol. xvi, p. 475; Falconer, ibid., pp. 99, 104; Baron Anca, ibid., p. 460. The last two notices may refer to a distinct species, as the animal is described merely as a large Felis.

to the same animal as the skull in that of the Rev. D. Williams. They were, however, among the bones from Sandford Hill, and were therefore described as from that cave in our first chapter. A closer examination has shown us that bones from different caverns in the Mendip can be recognised with much probability by their condition and the colour of the matrix. In both these respects the lower jaws strongly resemble the remains from Hutton. They exactly fit the spelæan skull from Hutton. We therefore suppose that they must have been accidentally misplaced either by Mr. Beard himself, or in the removal of his collection to Taunton, and that they really belong to the same animal that furnished the skull in the Hutton Cave to the Rev. D. Williams.

The skull in question is that of an adult rather past the prime of life. The teeth are decidedly worn, and the alveolus of the right upper tubercular molar is partially removed by absorption, which proves the loss of the tooth during the lifetime of the animal. Its state of preservation is shown by the following list of its component bones. A minute portion of the right nasal is present in the angle of the frontal suture, also small portions of the palatines adjoining the maxillary suture, and also that with the pre-sphenoid. The maxillaries with their dentition are nearly perfect, the palatine process being excepted. From the (otherwise perfect) inter-maxillaries the incisors have gone. The left third incisor was diseased, and probably lost during life. The right malar and squamosal are absolutely perfect, and the left nearly so. The posterior or cribriform plate of the ethmoid, and a part of its central plate, are present, so that the beautiful tracery with which it fills the anterior end of the cranial cavity may be seen by looking through the foramen magnum. The greater part, however, of the bone has disappeared. The vomer is entirely wanting. The pre-sphenoid and orbito-sphenoid are nearly perfect. The superior parts of both frontals are nearly perfect, but the orbital portions are much broken. The right tympanic bulla is perfect. The articular portion of the squamosal ("corsal" of Straus-Durkheim) is preserved on both sides, as also are the lower jaws, with the exception of the coronoid processes and a small portion of one of the condyles. The basi-sphenoids, ali-sphenoids, parietals, mastoids, basi-occipitals, exoccipitals, supra-occipitals, paro-occipitals, and Wormian, are nearly absolutely perfect. A small part of the lachrymals is attached to the frontals and maxillaries. The petrosals appear to be perfect, though of course they are but slightly visible.

The second skull (Pl. X) is from Mr. Beard's collection, and was found in Sandford Hill Cave. Along with it were found the lower jaws described in Chapter I and Pl. I of our work. They were accidentally labelled as coming from Bleadon, and the mistake transferred to our pages was not discovered until the chapter had gone to press. Both skull and lower jaws belong to a young adult. Several bones of an animal exactly corresponding in size and age were found along with them; and as those adjoining each other in the skeleton exactly fit, we have reason to believe that we have a considerable portion of the same individual. Unfortunately it was the practice of Mr. Beard "to restore," not very skilfully, the missing parts of crania and other fossils with hard plaster,

and in this case the result has been very great difficulty and risk in taking his work to pieces and articulating the skull for scientific purposes. After such rough usage the exactness of fit of the component parts and the symmetry have been to some extent lost. We have figured the skull as it stands now free from plaster, without attempting a restoration which very possibly might have been erroneous, and which certainly could have served no scientific end. The specimen retains a small piece of each nasal *in sitû*, and a large part of the right palatine. The right maxillary is all but perfect, with a small portion of the left. The right intermaxillary also is in part present. The only teeth remaining are the large premolars (four), and a portion of the right canine. Both premolars are nearly perfect, together with the left squamosal and a large part of the right, so that we can form an adequate idea of the size and form of the zygoma ticarch. The frontal bones are present, but their supra-orbital processes are much abraded. The left tympanic bulla is much broken, and the right is almost entirely gone. The basi-sphenoid is all but gone, and only the lower and posterior portions of the ali-sphenoid are left attached to the lower part of the ali-sphenoids and the squamosals. Both mastoids are imperfect. The basi-occipital is present, but the exoccipitals are abraded, and the supra-occipital is gone; and of the par-occipitals, only the left fossa remains.

In addition, we figure in Pl. XI the maxillaries and intermaxillaries of another specimen from Sandford Hill Cave, which is also from Mr. Beard's collection. It is of very large size, and exhibits the perfect adult dentition, with the exception of the small tubercular upper true molars, the small premolars (two), and one first incisor. We also give a figure of the articular portion of the squamosal of a gigantic animal from Bleadon Cave (Pl. IX, figs. 2 and 3).

Besides the skulls we figure, we have examined a large number of fragments, which are for the most part in the Taunton Museum, as well as the nearly perfect specimen from the Sundwig Cave, in Westphalia, now in the British Museum; from it are absent the greater part of the zygomatic arches, a portion of the left palatine, the pterygoid processes, the upper part of the supra-occipital, and two thirds of the nasals, the left orbito-sphenoid, together with the adjoining part of the frontal, the ethmoid, and the vomer. We have also examined the specimen figured by Professor Owen and Mr. Scharf from Kent's Hole, and a similar fragment from Muggendorf, now in the British Museum, and another like it from Ravenscliff in Gower, in the possession of Colonel Wood. These constitute the materials which we have at hand for writing this chapter on the skull of *Felis spelæa*. We shall compare the spelæan skull bone by bone with that of the living species most closely allied to it, that is, lion and tiger, beginning with the basi-occipital.

§ 2. *Basi-occipital.* (Pls. VIII, IX. No. 1).—The basi-occipital forms the posterior portion of the base of the skull, and is regarded as the centrum of the occipital vertebra by all who hold the "vertebral theory." From the slight bulging of the sides it

is somewhat hexagonal in form. It is rather longer than wide, and is slightly longer than the basi-sphenoid, to which it is firmly attached by a straight transverse suture. It forms a strong plate of bone of nearly uniform thickness, articulated behind to the exoccipitals in the whelp by a suture, of which the lateral portions are transverse. In the median line, however, it sends back a square process, the free end of which is the lower and anterior border of the foramen magnum. The lateral portions of this suture are interrupted by the "foramen condyloide," which passes from the posterior edge of the "foramen lacerum posterius" (*a*) to the interior of the cranium near the anterior border of the foramen magnum. This transmits the large motor hypoglossal nerve. The sides of the bone are in contact with rather than articulated to the tympanic, and above that to the petrosal, the junction between them being interrupted posteriorly by the large irregular "foramen lacerum posterius" (*a*) or "foramen jugulare" for the passage of the eighth pair of nerves and a large vein connected with the internal jugular. The medullary surface is somewhat concave, forming a lodgment for the "medulla oblongata." The flatness of the lower surface is broken by two large rough depressions on each side close to the tympanics for the insertion of the "recti antici majores" of the head, which take their rise in several roots on the pleurapophyses of the cervical vertebræ. Immediately behind them are the smoother but larger impressions of the "recti antici minores," which have their origin in the "atlas." These impressions are represented in Pl. VIII, in front of the "foramen lacerum posterius." In the median line we sometimes find in Lion the commencement of the tubercle for the attachment of the "constrictor pharyngis superior," which is, however, mainly attached to the basi-sphenoid. This does not occur, as far as we know, in *Felis spelæa*. With the exception, perhaps, of a slight tendency to greater width in the spelæan as compared with the leonine and tigrine basi-occipitals, there is no difference worthy of note.

§ 3. *Exoccipitals and Supra-occipitals.* (Pls. VI, VII, VIII, IX, X. Nos. 2, 3, 4).—It is more convenient for purposes of description to treat these as one bone rather than in accordance with their centres of ossification, because they are never found separate except in the very youngest individuals, and because, firmly anchylosed together, they form the main surface of connection between the head and the trunk. They compose a strong plate of bone, triangular in outline, firmly articulated to the basi-occipital (Pl. VIII, No. 1) at right angles, and with it circumscribing the foramen magnum (Pls. VIII, IX). On either side of the latter are two short thick pedicles of bone which point downwards and backwards, and support the condyles by which the head is articulated to the atlas. These point in their upper portion upwards, in the middle backwards, and in the lower downwards. Their edges project over the sides of the pedicle, forming a fossa, which is called the "condylian fossa" (*b*, Pls. VI and X). These are the portions termed by Professor Owen the exoccipitals (No. 2).

The two inferior angles of the bone are composed of the paroccipitals, or paramastoids,

as they are sometimes called, which form on either side a wide and deep cavity on the outer surface, which may be called the paramastoid fossa (*c*, Pls. VIII and IX), receiving the projecting sides of the glenoid cavity of the atlas, and thus combining great firmness of articulation with freedom of lateral motion. It runs as far downwards as the origin of the massive bony pedicle which projects downwards, and ends in the paramastoid tubercle (Pls. VI, VIII, IX, *d*), which is homologous with the jugular tubercle in man. The paroccipital articulates with the mastoid in front, and inferiorly with the tympanic; if we hold to the "vertebral theory" of the skull, as propounded by Professor Owen, it is homologous with the parapophysis of the basi-occipital vertebra. The portion of the occipital which composes the apex of the triangle, and together with the exoccipitals complete the arch over the spinal cord, is the supra-occipital (Pls. VI, VII, VIII, IX, No. 3), which would be the neural spine of the vertebra. Its sides are decidedly convex, while the continuation on the paroccipitals is concave, so that the whole side of the triangle is distinctly sigmoid; the interior and inner surface forms the back wall of the cranial cavity, and is entirely in contact with the cerebellum, for the convolutions of which it is deeply grooved and waved. The upper edges of the superior and outer surface are covered with high radiating ridges, of great sharpness and strength circumscribing depressions of various depth, which may be called the splenial fossæ (Pl. IX, *E*), from their being the points of insertion for the tendon of the great splenius muscle. That descending from the apex, remarkable for its size, serves for the attachment of the cervical ligament (ligamentum nuchæ).

The articulation of the exoccipitals with the basi-occipital has already been described in our account of that bone. Each of the paroccipitals (paramastoids) covers by a broad overlap the posterior end of the tympanic bulla. Above this it is firmly articulated to the posterior border of the mastoid through the whole length of that bone. Above this, in some individuals among the larger Feles, the supra-occipital articulates with the parietal, but generally the descending process of the Wormian or interparietal passes downwards so as to join the upper part of the mastoid and prevent the connection of the parietal with both the ex- and the supra-occipital. The suture with the Wormian is of great depth in the aged animals of the larger Feles, owing to the great height of the lambdoid or occipital crest. In advanced age the whole of the lambdoid suture is obliterated, and its position is marked by a very sharp and massive crest, the lambdoid or supra-occipital.

Ligaments and Muscles of Occiput.—A very detailed account of the muscles and ligaments of Felis are given in Straus-Durckheim's great work,[1] to which we would refer those who wish to become acquainted with the details of this part of the subject. We shall content ourselves with giving a list of the principal ligaments and muscles, with their

[1] 'Anatomie, descriptive et comparative, du chat, par Hercule Straus-Durckheim,' 2 vols. 4to, plates folio, Paris, 1845. This work is perhaps the most perfect monograph on the comparative anatomy of a single animal that exists in any language.

points of origin and insertion, so far as they are connected with the part of the skull under consideration.

The ligaments which connect the head with the neck are the following:—The cervical ligament, or "ligamentum nuchæ," which is comparatively small in the genus Felis, springs from the neural spine of the first dorsal vertebra, and passes among the muscles of the neck to its insertion on the summit of the occipital crest. The "atlo-cephalic capsular," the representative of the capsular of the head in man, occupies the position expressed by its name. It connects the skull, not only with the atlas, but also with the odontoid process of the axis. The "anterior superficial atlo-cephalic" is the equivalent of the "anterior cervical" in man. It springs from the anterior and upper border of the hypapophasis of the atlas, and is inserted into the posterior border of the basi-occipital. The "median superficial posterior atlo-cephalic," the posterior superficial of the atlas in man, fills the space between the upper part of the foramen magnum and the corresponding part of the atlas. It also extends down the sides of the posterior portion of the paroccipital fossa, which it connects with the exterior of the glenoid cavity of the atlas. The "rectus posterior capitis" has its origin in this ligament. The "deeper" ligament of the same name as the last appears to be simply the fibrous envelope of the spinal cord. The "anterior lateral atlo-cephalic," or ligament of the first vertebra in human anatomy, springs from the border of the glenoid cavity of the atlas, and is inserted into the basi-occipital on the inner border of the condyles. The "lateral atlo-cephalic," a strong ligament not found in man, has its insertion on the internal border of the paroccipital fossa, whence it passes downwards and backwards, and is attached to the inferior border of the glenoid cavity of the atlas. It hinders the excessive rotation of the head on the atlas. Two other smaller ligaments, having the same function, are called the "superficial," and the "deep transverse posterior," "atlo-cephalic." They have the same insertion as the last, but pass upwards and backwards to their points of attachment on the upper border of the neurapophysis of the atlas. They are not found in man. The "lateral odonto-cephalic," having the same name in man, closes the list; it passes from the end of the odontoid process to the inferior angle of each occipital condyle.

In giving a list of the muscles attached to this part of the skull, we will begin with those that serve for the movement of the whole head.

The great "complexus"[1] of man is represented in Felis by two muscles, that called "biventer cervicis" by Eustachius and Albinus, the "intersectus" of Straus-Durkheim, and that to which the latter author confines the name of "complexus." The insertion of the "intersectus" is on the inner portion of the occipital arch, over the foramen magnum. Thence it passes backwards, dividing into four principal tendinous roots, which are attached to the transverse processes of the seventh cervical and first three dorsal vertebræ. It adheres to the cervical ligament through its whole length. Above this lies the "com-

[1] Op. cit., vol. ii, p. 241 et seq.

plexus" proper, which has the same insertion as the preceding, and passes backwards to the diapophyses of the cervical vertebræ, and thence to the three anterior dorsals. The great, lesser, and middle recti posteriores of the head underlie these two muscles; their insertions extending nearly to the upper edge of the foramen magnum, and their origins being in the atlas and axis. These five muscles serve to lift up, and to a certain extent to rotate, the head. Their points of insertion are therefore necessarily of great strength in the larger and more powerful Feles. In *Felis spelæa* they are not more massive proportionally to the size of the animal than in the living tigers and lions.

The great splenius muscle springs from the "cervical ligament," and an aponeurosis which connects it with the last cervical and first five dorsals, and ends in a short strong tendon which is inserted into the occipital bone immediately behind the lambdoid suture. Its enormous size and strength in *Felis spelæa* is seen by the large fossæ for its insertion in Pl. IX, fig. 1. It takes part in the same movement as the preceding five muscles. The "trachelo-mastoid" of Douglas rises from five tendinous roots attached severally to the last four cervicals and the first dorsal, and passes in the form of a long thin band along the side of the neck to its insertion on the paroccipital. Near it is inserted the "rectus lateralis," which has its origin on the ala of the atlas. The "superior obliquus" of the head has nearly the same direction as the last, but passes within it to be inserted on the surface of the paroccipitals in the upper part of the condyloid fossa, at the point where they join the exoccipitals.

These three muscles, together with the splenius, bend the head from side to side. The great size of the lateral alæ of the atlas stands in direct relation to the development of these muscles, in animals that shake and worry their prey, such as lion, tiger, and *Felis spelæa*.

M. de Blainville[1] states that the occipital crest is prolonged further backwards in the tiger than in the lion, a point which we have remarked to be by no means of characteristic value, and that the condyles are more detached in the former than in the latter animal. We have frequently found the converse of this latter statement to be true. He also writes that in these two points the plaster cast of Count Münster's specimen of *Felis spelæa*[2] agrees with tiger and differs from lion. We are unable to lay hold of any character in the occipital bone that would differentiate lion from tiger or from *Felis spelæa*.

§ 4. *Basisphenoid* (Pl. VIII, No. 5).—The basisphenoid is articulated to the presphenoid by a transverse suture, which is clearly visible even in animals of considerable age. It is much wider though about the same length as this latter bone. The form of the inferior or guttural surface exposed in the perfect skull is roughly triangular, the apex of the triangle being cut off by the presphenoidal suture, and the base being formed by

[1] 'Ost. Felis,' p. 28. [2] 'Ost. Felis,' p. 108.

that with the basioccipital, which in the old animal is obliterated as completely as the frontal suture of human anatomy. The sides are covered to a great extent by the overlap of the anterior portion of the tympanic bulla, and in front by the guttural process of the alisphenoid. The surface in the larger Feles is nearly flat or slightly concave. A small foramen on each side of the basisphenoid in the suture between it and the alisphenoid is the posterior opening of the canal which conducts the Vidian nerve and artery to the foramen sphenoidale: from this proceeds a well-marked groove backwards along the above-named suture, to the foramen lacerum medium; it then passes along the suture between the tympanic and alisphenoid just outside the foramen caroticum, to the small foramen by which the nerve makes its exit from the petrosal proper, within which bone it branches from the facial nerve.

When detached the bone in the lion is of the same truncated triangular shape, but it is somewhat wider than was before apparent in consequence of the overlap before described. Its vertical thickness is slightly greater anteriorly than posteriorly, owing to the commencement of the upward slope from the bottom of the "sella turcica" to the olivary process within the cranial cavity. The dorsum ephippii rises to a considerable height in all the larger Feles, and is turned much forwards, the inclination from the summit to the posterior edge of the bone being at an angle of 30° to 35° with the horizontal. The sides of the "dorsum" expand into lateral alæ, somewhat like the wings of a moth, and homologous with the "posterior clinoid processes" in man. The arch formed by them, and the anterior clinoid processes is sometimes completed in Felis. We have not, however, met with an instance of this in the spelæan skulls: on each side of the "dorsum" is a furrow for the "internal carotid artery." Sometimes there is a small median foramen on the guttural surface, and two minute foramina on the back of the "dorsum ephippii."

Muscles.—The peristaphyline (Straus-Durckheim) muscle, the representative of the internal muscle of the same name in man, has its origin close to the alisphenoidal suture, at a point where it crosses a line joining the "foramina ovalia." Its office is to lower the "velum palati." The superior constrictor of the pharynx is attached to the posterior portion of the bone close to the basi-occipital suture.

The only point worthy of note in comparing this bone in *Felis spelæa* with those of lion and tiger is that it has a tendency to be somewhat wider in the two former animals than in the latter. This width, however, is very variable, and cannot be considered characteristic.

§ 5. *Alisphenoid; Pterygoid* (Plate VIII, No. 6).—The alisphenoid, usually described as the ala of the sphenoid, and treated by Straus-Durckheim[1] as a mere process of that bone, lies immediately in front of the squamosal in the surface of the cranium. As,

[1] Op. cit., vol. i, p. 395.

however, it is easily separated from the basi- and pre-sphenoid, while the suture between it and the pterygoid is obliterated at a very early age, we treat the alisphenoid and the pterygoid as one bone for descriptive purposes.

Nearly the whole of the outer surface of the bone is visible in the perfect skull, as a vertical plate running upwards to form part of the walls of the cranium between the temporal and optic fossæ. It also extends horizontally as far back as the petrosal, passing under the anterior part of the tympanic. Inferiorly, the pterygoids extend downwards and backwards on either side of the great guttural groove, ending in the thin, strong, hamular processes in lion and tiger, which in our spelæan skulls are unfortunately broken away. For purposes of description this compound bone may be divided into the horizontal or guttural portion, the supero-vertical or temporo-optic, and the infero-vertical or pterygoid portions. The first of these is a narrow plate, transversely concave, covering the postero-lateral edges of the guttural surface of the presphenoid and the antero-lateral edges of the basisphenoid. In the basisphenoidal suture is the orifice of the Vidian canal, by which the nerve and artery of that name enter the alisphenoid, and pass forwards into the orbit at the external border of the "foramen sphenoidale." We have already described the groove connected with this canal on the surface of the basisphenoid in our account of that bone (§ 4). The infero-vertical or pterygoidal processes curve downwards from the horizontal portion, and articulate anteriorly with the palatine by a vertical suture. The hamular processes, in which they terminate, are the equivalents of the internal pterygoid plates of human anatomy, the externals being represented by a slight longitudinal ridge immediately in front of the foramen sphenoidale.

M. de Blainville[1] states that the hamular processes of the tiger are less delicate than those of the lion. The variations, however, in this respect, in both these species, do not enable us to confirm this observation. As might be expected, these parts have not occurred in a fossil state.

The horizontal plate expands posteriorly behind the Vidian canal, and articulates with the squamosal just within the boundary of "the glenoid cavity." At this point it joins the supero-vertical or temporo-orbital process, which is a long, thin, triangular plate, highly convex externally, articulating behind with, and passing under, the squamosal by a highly concave suture, above with the antero-inferior angle of the parietal, in front with the postero-inferior angle of the frontal, and the orbito-sphenoid. At the bottom of this suture is a notch, which, together with a corresponding surface of the latter bone forms the large "foramen sphenoidale,"[2] to a certain extent the representative of the sphenoidal fissure or "foramen lacerum anterius"[3] in man, and giving passage to the third and fourth nerves, to the first branch of the fifth pair, or the trigeminal, and to the sixth. Immediately behind this, and rather lower down, is the foramen rotundum, for the trans-

[1] 'Ost. Felis,' p. 28. [2] Straus-Durckheim, op. cit., vol. i, p. 395.

[3] Holden, 'Human Osteology,' 3rd edit., p. 78.

mission of the maxillary portion of the trigeminal, and more widely separated and exactly opposite the glenoid cavity is the foramen ovale (*g*), which transmits the infra-maxillary, or mandibular branch of the fifth pair.[1] The latter is called the carotid foramen by M. de Blainville[2] and some others, in the mistaken belief that it transmits the carotid artery.

The foramen caroticum is in all the Feles extremely small; and the external orifice being entirely covered by the Eustachian process of the bulla, and generally, but not always, surrounded by the substance of that portion of the tympanic, it may be said to be within the foramen lacerum medium, immediately on the inner edge of the groove for the Vidian nerve. The internal orifice which is immediately in front of the apex of the petrosal proper leads directly to the groove for the artery described above as on the cerebral surface of the basisphenoid. This is very distinct in the smaller cats, but is less so in the larger. The foramen itself is larger in the jaguar than in any other large Felis that we have examined, admitting a small wire. It is very small in the tiger, and still smaller in a panther, and even in very young lions; in some old animals of both these species it appears to be entirely closed. In *Felis spelæa* it closely resembles the lion.

The functions of the carotid artery, as it exists in most other mammalia, appear to be supplemented, or rather replaced, by those of the numerous vessels which accompany the nerves in their passage through the different foramina, and which in this part of the skull unite an external "rete mirabile" to an internal, for the supply of blood to the brain. We have observed in many skulls of Felis that the large foramina of the alisphenoid are accompanied by smaller, which appear to be appropriated to the transmission of vessels, though we have not ascertained this to be the case by the actual dissection of those specimens.

Muscles.—The hamular processes of the pterygoidal portion of the alisphenoid being broken away, we can say nothing of the origin of the constrictor superior pharyngis, or of Folian muscle, in *Felis spelæa*. The origin of the circumflexus[3] (Albinus) is under the foramen ovale (*g*), whence it passes round the hamular process to its insertion in the velum palati.

§ 6. *Presphenoid and Orbito-sphenoid* (Pl. VIII, fig. 9).—All that hold the "vertebral theory" of the skull agree in assuming the homologies of the centrum of a vertebra for some part of the presphenoid, though there are differences of opinion as to the morphological value of the different parts. The bone is firmly anchylosed to the orbito-sphenoid while still fœtal, and the sutures have all but disappeared at birth; for this reason we describe them as one bone.

[1] Straus-Durckheim, op. cit., vol. i, p. 295. Holden, 'Human Osteology,' p. 395.

[2] 'Osteol. Felis,' p. 14.

[3] Straus-Durckheim, op. cit., vol. ii, p. 229.

In the smaller Taunton skull this bone is nearly perfect, and as the palate is broken away the anterior portion is visible. We are consequently able to describe all the free surfaces of the bone.

The visible portion of the inferior surface is a narrow strip, widening slightly posteriorly and considerably anteriorly, which forms the central portion of the roof of the posterior nares. The posterior portion is covered by a deep overlap of the pterygoid, and the anterior by a similar overlap of the palatine. The posterior end is firmly anchylosed to the basisphenoid by a deep suture convex posteriorly. These sutures are indicated in Pl. VIII, No. 9, by faint lines, as they are nearly obliterated in the skull by age. This surface is nearly flat in *Felis spelæa;* this is also the case in the majority of the lions' skulls that we have met with; whereas in the majority, if not all of the tigers' skulls, as well as in most of the other Feles, there is a strong longitudinal central ridge, which receives on each side of it the prolonged posterior processes of the vomer. Anteriorly the bone is seen to consist of a thickened central mass, which rises into a thin vertical plate, separating the ethmoidal sinuses, and articulating firmly with the central plate of the ethmoid, a portion of this articulation is seen in the skull we are describing. The central mass expands laterally into two thin plates, covered by the overlap of the palatine before mentioned, which form the floor of the ethmoidal sinuses, for the reception of the infra-lateral processes of the ethmoid, sometimes called the "cornets de Bertin."

The outer walls of these sinuses are formed by thin plates rising from the outer edges of the floor, at first inclining somewhat inwards, and covered by the overlap of the vertical plates of the palatine, but posteriorly these are uncovered, and arch over outwardly and form the lower and posterior surface of the orbit. This free portion is pierced on each side near the centre by the large optic foramina, which pass backwards and downwards to the optic groove on the cerebral surface of the bone; the lower part of this surface is traversed by a strong ridge, below which the bone is roughened for the insertion of the powerful Fallopian muscle for raising the lower jaw.

The roof of the ethmoidal sinuses is formed by a thick plate, narrow horizontally and anteriorly, but widening much posteriorly, at the same time curving downwards, so that it unites with the much thickened posterior end of the central mass at its junction with the presphenoid, forming at this point the homologue of the olivary process in man. Above, in front of this is the very deep transverse optic groove, the ends of which lead outwards, as before stated, to the optic foramina. The anterior portion of this, the cerebral surface of the bone, is the floor of the rhinencephalic fossa, the walls and roof of which are formed by the frontals. Anteriorly this surface rises centrally into a strong vertical ethmoidal spine, to which is anchylosed the cribriform plate, for the lower foramina of which the anterior edge of the orbito-sphenoid is deeply furrowed. The anterior edge of the vertical walls of the ethmoidal sinuses is articulated to the vertical walls of the palatine by firm sutures inclining forwards, to the frontals by nearly horizontal

sutures, which pass above the optic foramina, and to the alisphenoid by very firm sutures of considerable depth, which pass round the posterior portion of the bone, leaving on each side a considerable free space to form the inner surface of the foramen sphenoidale, the central and largest of the five foramina near each other in this part of the skull, which, as before stated, is homologous with the sphenoidal fissure, or foramen lacerum anterius in man.

The remaining muscles attached to this bone are the rectus externus of the eye; "grand abducteur" of Straus-Durckheim, and the "petit abducteur" of the same author, equivalent to a portion of the choanoid, which have their origin outside the optic foramen; and the rectus inferior, "grand abaisseur" of Straus-Durckheim, and the "petit abaisseur" of the same author, equivalent to another portion of the choanoid, have their origin immediately under the same foramen.

We have above indicated the only and very slight difference we have been able to distinguish on the guttural surface of the bone, between lion and *Felis spelæa* on the one hand, and most, if not all other Feles on the other.

§ 7. *Palatines* (Plates VI, VIII, X, XI, No. 20).—Of the palatines we have seen but a small portion in spelæan skulls from British localities but we are able to describe it fully from the skull, from the Sundwig cavern, preserved in the British Museum. It may be considered as composed of the horizontal naso-palatine portion, and the vertical plate that forms the lower surface of the optic fossa, its inner surface forming the floor and walls of the posterior nares. The naso-palatine portion presents a smooth horizontal surface joining its fellow by a thickened median symphysis, both forming a figure variably pentagonal in the bony roof of the mouth. Anteriorly it is firmly anchylosed to the maxillary by a serrated suture directed diagonally backward from the median line; posteriorly it presents a free edge that sends back a process to articulate with the pterygoid. The free edge forms the infero-posterior border of the posterior nares. Externally it joins at a right angle the vertical naso-optic process, along a line passing from the sectorial fossa (*h*) of the maxillary diagonally backwards to the pterygoid and the palato-maxillary suture; and nearly equidistant from the interpalatal suture and the sectorial fossa (*h*), is the small posterior palatal foramen (*i*) for the transmission of the palatal nerve. It is directed forwards, and opens upon a canal on the posterior surface of the maxillary. In some of the smaller Felidæ it is double, but in lion, tiger, panther, and all the larger species it is single, as in *Felis spelæa*. In all the leonine and tigrine skulls which we have examined, the position of this foramen is constant. It is much nearer to the postero-exterior border of the palate in lion than in tiger, when skulls of equal size are compared. The only apparent exception to this rule is presented by the skull of a small lioness in the British Museum, in which it is roofed in by an abnormal growth of bone from the maxillary, so that instead of opening as it usually does on, or rather in rear of, the suture, it is carried forward and opens far on the maxillary. We also find that in all the lions'

skulls we have examined, a thin probe passed through this foramen passes directly into the orbit without showing itself on the nasal surface of the bone, while in all, except in one or two extremely small skulls of the tiger, it passes freely into the nasal cavity. In both these points *Felis spelæa* agrees with lion.

To these M. de Blainville would add a third point of difference between lion and tiger: that in the lion the posterior border of the horizontal plates terminates in sharp cusps, which form a somewhat deep notch at the interpalatal suture, while in the tiger it ends in a point without a notch (en pointe médiane sans échancrure).[1] We have carefully tested the value of this point of difference in a large series of recent skulls. In leonine skulls the notch is variable in size, and in some almost obsolete. In those of tiger on the other hand the median point often disappears, leaving the posterior border straight, and sometimes well defined cusps are present, and the notch more distinctly marked than in some leonine skulls. Although, therefore, M. de Blainville has rightly indicated the tendency of the two species in this respect, we cannot suppose that we have in this the means of absolute distinction. The only skull of *Felis spelæa* which gives us information on this point is that from Sundwig. It shows in its present state an affinity to the tiger. The bone, however, is abraded at the point where the cusp would be, had it ever existed, and on the other side the palatine is restored in plaster. We therefore do not consider the evidence afforded by it of any value as to the leonine or tigrine character of the animal.

From the postero-external surface of the horizontal plate rises the vertical or optico-nasal, articulated by a slightly convex vertical suture to the inner side of the base of the malar process of the maxillary, and to the lower and posterior edge of the lachrymal, to the frontal above by a long horizontal suture, and to the lower edge of the orbito-sphenoid, and the anterior of the alisphenoid by a descending suture *en échellon*. The upper surface is slightly concave vertically and horizontally; the lower is convex vertically. It is pierced by two foramina, the larger of which is the spheno-palatine for the maxillary branch of the fifth pair of nerves; the smaller, situated more in front and at lower level, conducts the palatal nerve to the small posterior palatal foramen in the palato-maxillary suture. These two foramina are erroneously called by Straus-Durckheim "trous gustatifs."[2] To the lower part of the orbital surface, and throughout the whole length of the horizontal process, is attached the Fallopian[3] muscle, or external pterygoid of human anatomy, which is among those which elevate the lower jaw, and is inserted at the infero-exterior border of the horizontal ramus below the coronoid process. In man this muscle is inserted into the neck of the condyle and the meniscoid fibro-cartilage, and is a pretractor or rotator, while in Felis, being inserted much lower down, it serves merely for an elevator.

[1] 'Ost. Felis,' p. 28.
[2] Op. cit., vol. i, p. 426.
[3] 'Straus-Durckheim,' vol. ii, p. 217.

The only point of difference of specific value in this bone is in respect of the palatal foramen. In every case *Felis spelæa* agrees with lion in a most decided manner, the space between the foramen and the postero-exterior border of the palatine being even smaller in it than in the lion. In all the specimens of the panther and jaguar that we have examined, it is proportionally greater than in the tiger. *Felis spelæa*, then, is isolated from these two smaller species by this characteristic.

8. *Maxillaries* (Plates VI, VII, VIII, X, XI, No. 21).—The maxillaries of all the larger species of Felis resemble each other very closely, and yet it is in these very bones that we find minute differences which are specifically constant. Their surfaces may be described as the vertical or facial, the basal or palatine, the posterior or orbital, and the internal or ethmoidal. The first of these presents a roughly triangular outline, bounded behind by the malar, lachrymal, and frontal articulations; in front by those of the frontal, nasal, and intermaxillary, and below by the alveolar border. At its upper angle it is slightly concave; at the infero-anterior convex, for the reception of the fang of the canine, and at the infero-posterior flat. The concavity immediately behind the canine is the canine fossa, the muscle of that name passing along it from the malar to the upper lip. The upper angle forms the "frontal process," which is received into a deep notch in the frontal bone. It is truncated in the tiger, rounded in the jaguar, pointed or very rarely rounded in the lion and panther.[1] If a line be drawn joining the apices of the frontal processes, in the two former animals it falls below the extreme point of the frontal processes of the nasals, while in the two latter it falls above the nasals, and rests entirely on the frontals.[2] In two skulls of *Felis spelæa*, that figured in Pl. VII, and that from Sundwig, the frontal process is pointed, and the line rests on the frontals; in the third (Pl. X) the processes of the maxillaries are unfortunately abraded. If, however, the outline were restored, it would be impossible to make it otherwise than pointed; and if so, the line drawn from the frontal processses would also rest on the frontals without touching the nasal suture of these bones. Immediately opposite the superior portion of the malar suture is the great suborbital foramen, separated from the malar and the orbit by a stout bony arch, and giving passage to the suborbital nerve and artery. It is smaller, according to MM. Goldfuss, Cuvier, and de Blainville,[3] in tiger than in lion, and the arch is thicker; and those authors consider that in these respects *Felis spelæa* is tigrine in character. The specific value of these points is by no means confirmed by the study of a large series of skulls of lion and tiger, in which we find great variations in the

[1] We have seen some skulls which are said to be those of the panther or leopard from Eastern India and the peninsula of Malacca, in which the formation of the frontals and maxillaries resembled that of a tiger. The Western panthers, as far as our experience goes, all resemble the lion in this respect.

[2] This was first pointed out by Professor Owen, 'Proc. Zool. Soc.,' Jan. 1834, p. 1.

[3] Goldfuss., 'Nov. Act. Nat. Cur.,' vol. x; Cuvier, 'Oss. Foss.,' vol. iv, p. 453, ed. 1825; de Blainville, 'Ost. Felis,' p. 108.

proportions of their parts. We cannot, therefore, admit the tigrine affinity of *Felis spelæa* to be shown in the slightest degree either of the suborbital arch or foramen. From the postero-inferior angle of the facial surface springs the stout malar process, firmly articulated to the malar bone by an oblique suture. It is vertically convex on the outside; the inner side, vertically convex, horizontally concave, joins the posterior or orbital surface, which is inclined downwards from the suborbital foramen to the alveolar border behind the molar series, and articulates with the lachrymal and the vertical plate of the palatine. The orbital surface presents many small foramina for the nerves and arteries which supply the teeth, and affords attachment to the "inferior oblique muscle"[1] for the rotation of the eye, immediately below the lachrymal suture. The inferior or palatine surface is horizontal and very slightly concave in both directions. Posteriorly it is articulated to the horizontal plate of the palatine, on the inner side to its fellow, by a straight symphysis, which rises on the nasal surface into a sharp crest for the reception of the vomer. From the posterior palatine foramen (*i*),[2] which we have already described in the palato-maxillary suture, a broad shallow groove runs forwards the whole length of the bone, for the reception of the nerves and blood-vessels of the palate. In part it is joined to the premaxillary by a nearly straight suture, running obliquely forwards and outwards, passing into the alveolus of the canine, interrupted by a free oval space, which constitutes the posterior border of the naso-palatine canals. On its external edge is the alveolar border, for the reception of the canine and molar teeth, the alveoli of which will be described along with the dentition. At the postero-external angle is a round and deep cavity, which from its function of receiving the posterior blade of the lower sectorial molar may be called the sectorial fossa (*h*). The internal or nasal surface of the bone follows the contour of the palatine and facial surface. The large fangs, however, of the teeth necessitate large alveoli, which leave very little space for the antrum of human anatomy. To a ridge on the vertical portion of the surface the ethmoidal bone is attached.

Muscles.—To the facial surface of the bone the following muscles[3] are attached:—To the upper part of the frontal process the rhinæus, a double muscle for the elevation of the nostrils and upper lip; to the anterior edge of the orbit, close to the lachrymal suture, one of the roots of the palpebral, a muscle for the closing of the eyelids. Between these two points arises the elevator of the upper lip. The buccinator is not attached to the alveolar border, as in man, but is reduced in size, and confounded with the labial. The smaller branch of the lesser zygomatic springs from the alveolar border in front of the sectorial tooth, and its function is to aid in raising the lip. In no respect do the attachments of these muscles in *Felis spelæa* indicate any difference between that animal and the lion.

[1] Straus-Durckheim, op. cit., vol. ii, p. 207.

[2] These are erroneously termed "trous gustatifs" by Straus-Durckheim.

[3] Straus-Durckheim, op. cit., vol. ii, pp. 203, 207, 210, 211.

§ 9. *Intermaxillary* (Pls. VI, VII, VIII, X, XI, No. 22).—The inter- or pre-maxillaries form the anterior end of the face, and consist, like the maxillaries, of an ascending and an horizontal process. The first of these, which may be called the nasal process, is wedged in between the maxillary bone below and the nasal above, forming part of the lower portion of the alveolus of the canine, and is to a great extent overlapped by those two bones. The horizontal, incisive, or palatal process is articulated behind to the palatine process of the maxillary, and in the median line to its fellow by a straight symphysis, strengthened by a ridge on the superior or nasal surface, which with its fellow ridge forms a trough, which is articulated to and forms a continuation of the vomer. The palatine suture is interrupted by the two large oval naso-palatine foramina (*k*), which open into two grooves that pass forwards as far as the inner edge of the incisive border. The incisive border in front forms an arc of a large circle, and is separated from the alveolus of the canine by a shallow excavation for the reception of the canine of the lower jaw.

The intermaxillary bones form the lower and lateral boundaries of the nostrils, and present us with a character of specific value[1] by which we can separate lion from tiger. In viewing the lower half of the nasal aperture in front, its inner bounding line takes the form of an even curve, expanding regularly in the former animal, while in the latter it is distinctly a surface of double curvature. This character is more strongly impressed on the larger than the smaller skulls. In *Felis spelæa* it is strongly marked, and its evidence as to the leonine character of that animal is beyond doubt. The Sundwig skull, however, is somewhat exceptional, showing a tendency towards the double curvature of tiger, but the tendency is not greater than that presented by several small skulls of lion. The nasal, or ascending, is inclined backwards at an angle of from 50° to 60° with the horizontal process in Leo, Tigris, and *Felis spelæa*, the angle being greatest in the largest skulls.

Muscles.—The myrtiform[2] muscle for the dilation of the nostril, and the moustache muscle for the protrusion of the lip, take their origin from this bone; the one from the sides of the nasal aperture, and the other from the median suture.

§ 10. *Petrosal; Mastoid; Tympanic* (Pls. VI, VIII, IX, Nos. 16, 8, 28).—In the description of these bones we adopt Professor Owen's numbers and nomenclature, without committing ourselves to his views of their homologies, rather than enter into a discussion which has no immediate bearing on our present work. We shall therefore describe the petrous bone, together with the posterior descending process, as the petro-mastoid, and the remainder of the acoustic organ as the tympanic.

[1] This difference is pointed out by M. de Blainville, 'Ost. Felis,' p. 28.

[2] Straus-Durckheim, op. cit., vol. ii, pp. 208, 209.

The petrosal proper is so irregular in shape as almost to defy description. It may, however, be conceived as resembling a dried distorted pear, lying diagonally across the axis of the skull, so that the pointed end or stem points forwards, inwards, and somewhat downwards. It has three well-marked sides or divisions, the intero-posterior or cerebellar, the superior or tentorial, and the extero-anterior or tympanic. There is also a smooth, rounded, triangular surface between the posterior edges of the tympanic and cerebellar surfaces, which is partly in contact with the paroccipital (paramastoid), and partly forms the inner surface of the "foramen lacerum posterius." The names of these surfaces adequately show the position of the bone in the skull, for it is wedged in between the basi-occipital, the tentorium, and the tympanic, the inner surface alone being exposed on the side wall of the cerebellar cavity. The inferior edge between the cerebellar and tympanic surfaces is in contact with the exterior edge of the basi-occipital, the outer portion of the tentorial with the lower or inner edge of the squamosal, and the anterior apex of the stem reaches as far forwards as the extero-posterior angle of the basi-sphenoid. The cerebellar surface of the petrosal proper is roughly elliptical in form, having the anterior end pointed. A low ridge, running diagonally upwards and forwards, divides it into two long, shallow depressions. Near the middle of the lower depression is the "meatus auditorius internus," a foramen somewhat C-shaped externally, but divided internally into two canals, the one for carrying the facial-motor nerve, the other for the body of the acoustic nerve before its distribution in the cochlea and semi-circular canals. In the middle of the upper depression is the small foramen of the "aquæductus vestibuli," as in man. That of the aquæductus cochleæ is under the meatus auditorius, opening into the petrosal sinus, rather further back than in man. The antero-inferior edge of this surface is, as we have said, in contact with the basi-occipital. Between the two is the "infra-petrosal sinus," which ends posteriorly in the "foramen lacerum posterius" (*a*), a large opening left between the petrosal, the tympanic bulla, and the basi- and par-occipitals. This gives exit to the jugular vein and the eighth pair of nerves.

We are unwilling to pull to pieces the skulls of *Felis spelæa*, and therefore cannot describe the other three surfaces of the petrosal that are hidden in the perfect crania. A glance at the disarticulated skull of lion or tiger will convey a more adequate notion of it in *Felis spelæa* than we could convey by the most faithful word-painting.

Mastoid.—Firmly soldered to the posterior edge of the petrosal is a massive wedge-shaped-bone (No. 8), the thin end of the wedge passing upwards between the squamous bone and the paroccipitals, and the thick rounded head projecting freely downwards (*l*). Though cartilaginous in the young Feles, and incompletely ossified even at the age of five months after birth in the lion, it becomes very compact and hard in the adult animal, and perfectly coalesces with the squamosal and petrosal, the suture with the former being a continuation of the lambdoid suture, and rising into a sharp ridge continuous with the occipital crest. In the majority of leonine and tigrine skulls the narrow ascending process

does not reach so high as the parietal. The lower internal surface of the thick rounded head of the wedge is concave and smooth, and is closely applied to the posterior surface of the tympanic bulla, with which it has no further connection. The free end bears the articular surface for the stylohyal. This point, therefore, represents the styloid process in man. We have ascertained that in this bone there are no mastoidal cells, similar to those in the mastoid of man, connected with the tympanic, their absence in the Felidæ being compensated for by the large tympanic bulla. In spite of this significant fact, bearing on the "vertebral theory" of the skull of Carnivora, we use Professor Owen's name of "mastoid" for the bone in question, without discussing the value of the many and conflicting theories of the homologies of the component parts of the cranium.

Tympanic.—The tympanic bone consists of two portions—the tympanic proper, and the bulla or supplementary portion. The tympanic proper forms a somewhat compressed oval chamber, the outer, upper, and posterior walls of which are in part firmly articulated to, and partly formed by, the inferior edge of the squamosal between the glenoid cavity and the mastoid, and which is directed from the latter downwards, inwards, and slightly forwards, parallel to the tympanic bulla. Externally it presents an oval opening under the supra-mastoid ridge of the squamosal—the "meatus auditorius externus" (*m*). This is the original portion of the bone which is in the young animal simply a thin plate, resembling a horseshoe in form, attached by the two ends to the squamosal, which thus completes the ring. Across it is stretched the membrana tympani, like the parchment over the head of a drum, the centre receiving the handle of the malleus. The outer surface of the chamber curves slightly forwards, downwards, and inwards (*n*), in front of the bulla, and it is much roughened for the attachment of the posterior branches of the stylo-maxillary ligament. In the anterior part of the articulation with the squamosal is the glenoid fissure. The anterior end of the bone turns downwards, and forms one or two small, thin, hooked processes (*n*), which are irregular in shape and number, and overhang the foramen lacerum medium, a large irregular cavity formed by the junction of the bulla, the posterior processes of the basi- and ali-sphenoids, and the petrosal. It transmits the canals for the Eustachian tube, the groove for the Vidian nerve and artery, and has within it the external orifice of the foramen caroticum. It is called, erroneously, in our opinion, "le trou déchiré antérieur" by Straus-Durckheim.

Inside the "meatus auditorius" a long septum or curtain partially divides the chamber, and forms a deep groove, open downwards, which passes under and in front of the "meatus." The inner wall of the chamber is formed by a thin plate of bone, that divides it from the bulla. It is said by Straus-Durckheim to be double in the cat. We have, however, examined it in the adult cat with a powerful microscope, and it appears to be homogeneous in structure throughout. The lower surface of the petrosal roofs in and thus completes the chamber, being soldered to the tympanic by exceedingly thin though firm connections at the posterior and upper borders of the cavity. The tympanic

bulla, always present in the skulls of Carnivora, and very largely developed in the genus Felis, is a large chamber of oval shape, wedged in between the basi- and par-occipitals, the mastoids, and the petrosal. Its external walls are very compact and hard, though thin, and appear under the microscope to be somewhat fibrous in structure. It is closed on all sides, excepting at the top, where there is a long fissure, in which the promontorium of the petrosal lies in such a position that the "fenestra vestibularis" opens directly on the interior of the bullar cavity. The latter passes into the chamber of the tympanic proper. The bulla thus performs the same functions as the mastoid cells in man, and is consequently called the mastoid by Straus-Durckheim and some other anatomists. In front the bulla sends forward a long, solid, pointed process, that passes between, and articulates with the posterior processes of the basi- and the ali-sphenoid. On the inside it is in contact with the external and lower border of the basi-occipital, and with the whole length of the petrosal. Its relations to the mastoid and paroccipital, to the foramen lacerum medium, and the "stylo-mastoid" foramen, have been already described. In comparing these bones with those of the large Feles we labour under the disadvantage of being able to see but a small portion of them in the perfect skulls. So far, however, as we have been able to institute a comparison, the difference between the spelæan and leonine bones is so small that it is scarcely worthy of note. There is absolutely no difference between the cerebellar surfaces of the petrosal. As compared with those of tigers, the inter-tympanic width is greater in the Taunton skulls than in several skulls of tigers of similar size. The foramen lacerum posterius is shorter and rounder in lions and *Felis spelæa* than in the majority of tigers' skulls. These points, however, are of no great value, and are certainly not characteristic. They show merely the leonine character of these bones of *Felis spelæa*, which in the course of this Monograph we shall be able to trace throughout the rest of the skeleton.

Malleus (Pl. X, figs. 2, 3).—We found that in the tympanic of the larger skull at Taunton the malleus still existed in its original position, and nearly perfect. We extracted it, and are consequently able to give figures of it and describe it. The long process (the "manubrium mallei"), which in the living animal rested on the drum of the tympanic, sloped downwards and forwards, while the condyle-like head was articulated very slightly to the upper part of the tympanic cavity, formed by the external edge of the petrosal and the inferior and inner edge of the squamosal. The neck of the bone is bent inwards and upwards, and posteriorly there is a small facet for the incal articulation; on the opposite side of the neck from that to which the manubrium is attached a small sharp process rises, which affords insertion to the Eustachian muscle[1] ("internus mallei"). In the living lion a thin plate of bone fills up the acute angle formed by the neck; this is broken in the fossil. Two other small processes rise from the opposite side of the neck to the Eustachian process, which appear to be homologous with the processi longus

[1] Straus-Durckheim, op. cit., vol. i, p. 416.

or gracilis and brevis of human anatomy. A comparison of the bone with those of lion, tiger, panther, and jaguar showed no essential point of difference.

§ 11. *Squamosal* (Pls. VI, VII, VIII, IX, X, No. 27).—The squamosal consists of a slightly convex scale-like process applied to the exterior of the sides of the cranium, and a stout articular process, which rises at right angles, and forms the pedicle supporting the lower jaw. The former overlaps the ends of the following sutures, commencing anteriorly, and passing upwards round the edge:—the alisphenoid, parietal, mastoid, petrosal, and tympanic. It is so firmly soldered to the mastoid posteriorly that all trace of the suture is obliterated in the adult. In the young skull, however, of *Felis spelæa* (Pl. X, *o*) it is articulated so loosely that the mastoids have been broken away along the line of weakness thus presented. In the fully grown animal, however, the squamosal, mastoid, petrosal, and tympanic, form one bony mass, which is the exact homologue of the temporal bone of human anatomy. With the parietal it is articulated superiorly by a long horizontal, and with the alisphenoid by a vertical, suture, that ends in the glenoid fissure below. A small part only of the centre of the bone appears in the inner wall of the cranial cavity. From the lower and anterior angle of the squamous portion springs the strong pyramidal articular process, triangular in section, with its antero-inferior border deeply excavated, so as to form a transverse horizontal groove, which is the glenoid cavity (*p*) for the reception of the condyle of the lower jaw. On the postero-inferior surface it is slightly convex, on the superior somewhat concave. At from two to three inches from its origin it suddenly turns forwards at right angles to its long axis, becomes much compressed vertically, and is articulated by a long splice or diagonal suture to the malar, by which it is overlapped externally. A strong sigmoid ridge (*q*), equivalent to the "supra-mastoid ridge" in man, passes forwards from the lower edge of the squamous portion at its juncture with the mastoid, is carried round the upper and posterior edge of the articular process, and forms the upper edge of the zygomatic portion of the bone. Underlying this ridge, at the point where the squamous and articular portions meet, is the meatus auditorius externus (*m*), or external orifice of the ear, of which the upper edge is formed by the free surface of the bone. At the origin of the ridge, which from its position we may call the squamosal, and abutting against the inferior process of the mastoid, to which it is firmly soldered, is a strong process, in length equal to the latter, that supports the stylo-articular ligament. The depression at its end is marked *r* in Pl. VIII.

Muscles.—The whole space between the zygomatic arch and the cranium is filled by the masses of the great tearing and rending muscle which gives such enormous power to the jaws of the Felidæ and Hyænidæ—the "crotaphite," or temporal. Its first branch is in part attached to the inner side of the articular process above the malar articulation. The second springs from the squamous portion above the articular process, and the third is partially attached to the general surface of the squamous portion of the base. The

second branch of the masseter also springs in part from the inferior edge of the zygomatic arch, and from the edge of the glenoid cavity.

MM. Goldfuss and Cuvier[1] agree in stating that the height of the zygomatic arch in *Felis spelæa* is greater than in either the lion or the tiger, while according to M. de Blainville[2] it is wider in *Felis spelæa* and tiger than in the lion. He adds also that the articular process rises from the temporal portion of the squamosal at more nearly a right angle in *Felis spelæa* than in lion. On testing the value of these points in a large series of leonine and tigrine skulls, we cannot admit them to be of specific value; and after comparing the two skulls of *Felis spelæa* in the Taunton Museum with those of both those species, we cannot lay hold of any character by which we can separate one from the other so far as this bone is concerned.

We figure in Pl. IX, fig. 2, a fragment of the articular portion of a squamosal from Bleadon Cavern, which is very much larger than any other we have met with, either recent or fossil.

§ 12. *Malar or Jugal* (Pls. VI, VII, VIII, X, No. 26).—The malar is a thin quadrangular bone which forms the anterior portion of the zygomatic arch, and stands out from the skull so as to form an angle of from 40° to 45° with the median plane, the angle being smaller in the younger than the older animals. This difference is very evident if we compare the young skull figured in Pl. X with the old one in Pl. VII. In front it is articulated to the maxillary, and a small process passes inwards, forming the inferior border of the orbit, and the upper half of the bridge over the infra-orbital foramen, to articulate with the lachrymal. Behind it joins the zygomatic portion of the squamosal by a very oblique suture, which passes diagonally upwards, inwards, and forwards, as far as the plane of the suborbital process (*s*). This latter is a strong, flattened, triangular mass of bone, produced into a sharp angle pointing upwards and backwards, connected in the living animal with the supra-orbital process of the frontal (*t*) by the fronto-malar ligament (gonio-malar[3] of Straus-Durckheim) which completes, with the frontal, malar, lachrymal, and maxillary, the orbit. From this ligament, as well as to the posterior part of the sub-orbital process, rises a portion of the large temporal or crotaphite muscle, which fills nearly the whole of the temporal fossa. Along the outer surface a ridge of considerable prominence runs parallel to the lower free concave edge of the bone, which affords an origin to the first portion of the masseter muscle, the second springing from the inner surface, without leaving any impression on the bone to mark its position. The infero-exterior surface also affords attachments in front to the "lesser zygomatic muscle"[4]

[1] 'Oss. Foss.,' vol. iv, p. 463, ed. 1825.

[2] 'Ost. Felis,' p. 108.

[3] Straus-Durckheim, op. cit., vol. ii, p. 14.

[4] Ibid., p. 210.

for the elevation of the lip; and within this to the wide thin "canine," which takes part in the same office.

The malar bone presents no point of specific difference in lion, tiger, and *Felis spelæa;* a comparison of upwards of one hundred skulls having convinced us that the character of greater depth in the latter than the two former animals, insisted upon by MM. Cuvier and Goldfuss, is not of specific value. The sub-orbital process, however, appears to be set rather further backwards in the majority of leonine skulls than in those of the tiger, so that the orbit is wider and rounder in the former than the latter animal. In this point *Felis spelæa* certainly agrees with the lion.

In the recent animal the whole orbit is surrounded by a strong deep ligament, resting on its edge, which renders it deeper and more complete.

§ 13. *Lachrymal* (Pls. VI, VII, X, No. 73).—The lachrymal bone occupies the anterior border of the orbit, and is articulated in front to the maxillary, behind to the frontal, below to the palatine, maxillary, and malar bones. It is a flat plate, of irregular form, varying from triangular to quadrilateral. Its greater part is within the orbit in the larger Feles, but the small portion adjoining the frontal process of the maxillary is continuous with the external surface of the skull. At its superior angle is the palpebral tuberosity (*u*) for the insertion of the palpebral muscle, and below it is the lachrymal foramen (*v*), sometimes excavated in the lachrymal, at others lying in the lachrymo-maxillary suture that runs downwards into the nasal cavity. The internal surface of the bone is ridged for articulation with a branch of the ethmoid. The sutures vary in direction according to the shape of the bone. In old animals they are almost entirely obliterated; a small flat bone, "os planum," is sometimes, though rarely, intercalated in Felis at the infero-internal angle. There is no appreciable difference in the shape of this bone in tiger, lion, and *Felis spelæa*.

§ 14. *Ethmoid.*—It cannot be expected that any large part of so fragile a bone as the ethmoid can be preserved in the fossil state; but as an important part occurs in one of our specimens, we describe the bone in the lion and tiger. In the genus Felis the ethmoid fills the great facial cavity, and may be considered as consisting of a central plate flanked on either side by a highly convoluted mass of bone, and a transverse vertical plate. The former is vertical, and firmly articulated to the ethmoidal spine of the pre-sphenoid, as well as to the vertical plate which divides the ethmoidal sinuses; it rests on the vomer; it is also articulated to the median nasal crest of the symphysis of the frontal bones, and passes more than half way towards the anterior end of the nostrils. It is considered by Professor Huxley[1] as the continuation of the basis cranii

[1] 'Proc. Royal Society,' No. 33, "Croonian Lecture," 1858, p. 433.

formed by the basi-occipital and the basi- and pre-sphenoids, in opposition to the more strict vertebral theory of Professor Owen,[1] who considers the vomer as the centrum of the nasal vertebra. The posterior edge of the plate expands laterally into a transverse, nearly vertical plate, concave posteriorly, which closes the anterior end of the cranial cavity; from its being full of small foramina this is called the cribriform plate. From the lower and outer edges of these two plates spring others remarkable for their thinness and delicacy, which form a highly complicated tissue-like mass of bone, filling the greater part of the facial cavity, and sending prolongations upwards and backwards into the frontal sinuses, backwards and downwards into the anterior sinuses of the pre-sphenoid, and forwards into the nostrils. This mass is attached to the maxillaries, the frontals, vomer, and presphenoid, by delicate and thin articulations; and the whole is so arranged that the air breathed through the nostrils must pass over the greater part of its surface. Through the foramina in the cribriform plate pass the branches of the olfactory nerves, which are spread over the large surface afforded by the convolutions of the bone. The whole mass thus described is called a sense-capsule by Professor Owen.[2] This bone is naturally highly complicated in animals endowed with a fine sense of smell, such as the Felidæ. In the common cat it looks like a mass of lightly squeezed silver-paper. In the larger Feles it is of course somewhat thicker and coarser, and more slightly packed, but it is still of great delicacy and beauty. The pattern of the foramina in the cribriform plate may, perhaps, vary in the different species, but the position of the bone in the skull renders a comparison difficult and uncertain. In the smaller skull of *Felis spelæa* the plate appears like a beautiful plate of Saracenic tracery filling the end of the cranial cavity when viewed through the foramen magnum.

§ 15. *Wormian* (Pls. VI, VII, IX).—The Wormian or inter-parietal is a small triangular bone occupying the apex of the occipital crest, and firmly wedged in between the parietal and supra-occipital, the sutures being of considerable depth. The development of its downward processes is very variable, but sometimes they extend down to the squamosal, and even the mastoid, thus separating the supra-occipitals from the parietals. Its inferior surface forms the highest part of the cranial cavity.

Muscles.—The Wormian bone gives origin to several small muscles that regulate the movement of the ear; for their names we refer to the second volume of Straus-Durckheim's great work on the cat, which we have so often quoted.

§ 16. *Parietals* (Pls. VI, VII, IX, No. 7).—The parietals form the roof of the greater part of the cerebral cavity, and appear on the exterior of the skull as two nearly rectan-

[1] 'Homol. Vert. Skel.,' pls. 1 and 3.
[2] Ibid., pls. 2 and 3.

gular plates, convex vertically and horizontally, and thin except at the point of junction, where they form the strong sagittal crest for the attachment of the third branch of the temporal muscle. This crest increases in size and height, as in the recent Felidæ, in proportion to the age, being almost obsolete in the young animal that has not yet had time to use his jaws for tearing and rending, and gradually increasing in size in proportion to the age, and consequently the increased use of the temporal muscle, until it reaches its maximum in the old tiger. From the lower anterior angle of the bone a process is sent downwards and forwards to meet the alisphenoid, on which frequently in old lions, and in the smaller spelæan skull in Taunton, there is frequently a strong ridge defining the points of attachment of the second and third branches of the temporal muscle. The size and situation of this ridge recall the vast parietal processes in the genus Otaria, in which also the ramal process of the lower jaw, described by us as characteristic of lion and *Felis spelæa*, is enormously developed. Anteriorly they overlap the frontals by a straight suture; posteriorly they are overlapped by the Wormian; but in old age the latter suture is obliterated; it is very variable in position in the larger Feles, generally running clear of, and in front of, the occipital crest, but sometimes occurring in the crest itself. Inferiorly they are to a great extent covered by the squamosals, which almost entirely conceal their alisphenoidal processes, and entirely their long posterior processes, which may be called "petrosal," from their close contact with those bones.

Internal surface.—A plate, thin in the smaller but very thick and strong in the larger Feles, projects downwards from the cranial surface of the parietals, running diagonally forwards from the posterior angle of the symphysis to the petrosal process, where it is united to a small corresponding plate on the alisphenoid. This plate, with its fellow of the opposite side, forms the "tentorium" (Pl. X), or ossified[1] curtain of the "dura mater," that divides the cerebrum from the cerebellum. In the centre of the united processes is an arch rather more than half the height, and about one third of the width of the cranial cavity, which admits of the connection of the cerebrum and cerebellum. The symphysis between them projects forwards into a ridge, which is high and sharp in the larger Felidæ, and which sends down a sharp spine, which may be called the tentorial. This latter is present in tiger, but altogether wanting in lion and *Felis spelæa.* In the former, also, the arch appears to be narrower than in the two latter.

The whole of the cranial surface of the parietal and tentorium is ridged and furrowed for the convolutions of the brain.

Nearly the whole of the temporal surface of the bone is occupied by the great third branch of the temporal muscle, which has its principal attachments along the posterior part of the sagittal crest. The other muscles associated with the sagittal crest are small, and spring rather from the Wormian, and the front of the occipital crest rather than from the parietal. They are all connected with the movement of the ear, and are termed by

[1] Pl. X, "tentorium."

Straus-Durckheim "sagitto-pavillien," "occipito-pavillien," and occipito-scutien.[1] The first appears to have a retrorsal and the others a rotary action on that organ. There are also many other small muscles connected with the movement of the ear, for which we would refer to the pages of the author we have so often quoted on the myology of the cat.

The proportions of the Wormian and parietals are not constant in the skulls of the larger species of Felidæ. There is, however, a tendency in those of the adult tiger to a greater development of the whole of the posterior and upper solid mass at the juncture of the sagittal and occipital crests than in those of the oldest lion. It also has a greater upward projection, which gives to the tigrine skull the "serpentine" outline, which Cuvier considers characteristic.[2] The examination, however, of a very large number of skulls shows their variability in this respect, and compels us to look upon it as a tendency only. In the straightness, and even in one case the downward curvature, of this portion of the sagittal crest, *Felis spelæa* agrees with *Felis leo*.

§ 17. *Frontals* (Pls. VI, VII, VIII, IX, X, No. 11).—The frontals in many, if not most, mammalia, present characteristics of more or less specific value, and especially in the leonine and tigrine skulls. They roof in the highest and most central region of the carnivorous skull, whether taken longitudinally or transversely. Each presents the following surfaces:—The superior or coronal, the antero-lateral or orbital, the postero-lateral or temporal, the postero-internal or cerebral, and the antero-internal, nasal, or ethmoidal. There are also two other surfaces, the median or symphysial, by which each is united to its fellow, and the parietal, a deep triangular suture, inclined diagonally backwards and downwards. Of this latter the great depth and deeply serrated structure is well seen in the spelæan skull, Pl. X, the parietals having been broken away. The superior or coronal surface of each half is somewhat triangular in form, the interfrontal portion of the sagittal suture being straight, up to the point of junction with the nasals, where the edge curves outwards and passes under the latter bones. This edge, about one inch and a half more or less in length, ends in a sharp point, where it meets the maxillary. It then sweeps backwards, parallel to the median line, forming a deep notch for the reception of the frontal process (*i*) of the maxillary, by which it is overlapped. The process of the frontal thus lying between the nasal and the maxillary may be called the naso-maxillary process (*w*). It is proved, by an examination of a large series of skulls, to be wider in lion and *Felis spelæa* than in the tiger. From the top of the frontal process the fronto-maxillary suture passes forwards and downwards to meet the lachrymals. The edge of the bone, then passing backwards into the orbit, is articulated to the latter bone by a suture directed diagonally downwards and backwards, from the latter of which it is connected with the palatine and orbito-sphenoid by a long horizontal suture. It then on the

[1] Op. cit., vol. ii, pp. 195 et seq.

[2] 'Oss. Foss.,' vol. iv, p. 453.

temporal surface is united to the temporal process of the alisphenoid by a small process passing into the anterior and upper angle of that bone. Thence it passes obliquely backwards to join the straight, transverse, parieto-frontal suture, that has already been described.

The boundary between the frontal and orbital surfaces is the "superciliary" ridge, that between the frontal and temporal the "temporal;" and these two unite in the massive supra-orbital process (*t*). The frontal surface is generally wider and flatter in the fully adult lion than in the tiger; and in the latter animal it rises on either side of the inter-frontal suture into a well-defined rounded elevation, so that the entire mass of the supra-orbital process is directed more decidedly downwards than in the former animal. In lion the surface is more or less widely concave, and the mass of the supra-orbital process is nearly horizontal, the point only being directed downwards. Some aged skulls of lion, however, and particularly in the smaller varieties, approach those of the tiger in this respect; and the young of each species are, as one might expect, to be determined only with great difficulty as far as this character is concerned. But as we can discriminate adult leonine skulls from those of tiger in every case that has come before us by this character alone, we believe that it is tolerably constant. The smaller spelæan skull (Pl. IX) agrees with the average and therefore typical lion in the possession of this characteristic, as also does the larger specimen (Pl. X), so far as its abraded condition allows us to judge. The small skull in the British Museum, from Sundwig, on the other hand, is somewhat tigrine in this respect, but not more so than small skulls of *Felis leo* in the same collection. Across the inter-frontal suture, at a small distance from the nasal notch, a semilunar depression[1] exists in many skulls of tiger, that is only slightly indicated in those of lion. We do not, however, find this constant. In all the three spelæan skulls this depression is absent.

The temporal ridges bounding the posterior part of the frontal surface pass diagonally backwards from the supra-orbital process on either side to unite in the sagittal crest. In the young of the larger and in the adult of the smaller *Feles*, they pass far over the parietal before they join, so that the sagittal crest does not reach as far forwards as the frontal bone. In the adult tiger it passes over the parieto-frontal suture, sometimes to the extent of an inch and a half before its point of junction with the ridges, while in the adult lion its extent on the frontal bone is very small, and in many cases the temporal ridges extend as far back as the parieto-frontal suture. In this respect the smaller skull of *Felis spelæa* (Pl. IX), which is that of an old animal, is typically leonine, and the larger, though younger, figured in (Pl. X), shows the same tendency, as does also, though in a somewhat less degree, that from Sundwig. Also, if a line be drawn across the frontal surface joining the posterior edges of the supra-orbital processes, and from the point where it cuts the inter-frontal suture a measurement be taken to the fronto-parietal

[1] See Owen, 'Proceed. Zool. Soc.,' Jan., 1834, p. 1.

suture, we get the temporal length of the frontal bone. If this be taken proportionally to the basal length of the skull, it is, so far as our experience goes, invariably greater in tiger than in lion; the nearest approach to an equality being afforded by a very small tigrine skull in the Oxford Museum, from the Himalayah, and a large Gambian lion (112 *d*) in the British Museum.

The orbital surface may be considered as a section of the interior of a hollow cone, of which the apex is directed obliquely backwards and downwards. The greater projection of the supra-orbital process causes the concavity to be deeper in lion and *Felis spelæa* than in tiger. It is pierced near the palatine suture by the small "internal posterior orbital foramen," homologous with that in the human fronto-palatine suture. It serves for the passage of the ethmoidal nerve and artery from the orbit into the anterior end of the cranial cavity, close to the cribriform plate. The postero-external or temporal surface is highly convex vertically, and extends to the temporal ridges and the sagittal crest where the latter reaches the frontals. It roofs in the anterior portion of the cerebral cavity. In old animals of lion and tiger strong ridges are sometimes present in the lower part, directed obliquely upwards and forwards. The mass of solid bone immediately over the anterior lobes of the cerebrum is of great thickness for the size of the animal, being 1·55 inches in the larger spelæan skull (Pl. X), and 1·54 in a lion in our own possession. The cerebral surface is deeply concave, and excavated for the convolutions of the brain, and for the arteries. A slight groove marks the inter-frontal suture. The vault formed by the cerebral surfaces of the frontals is interrupted anteriorly by an oval arch of about half its height. It leads anteriorly into a chamber, the rhinencephalic fossa, the end of which is closed by the beautiful tracery of the cribriform plate. The abutments of the arch are of great strength. The latter is the equivalent of the "ethmoidal notch" in man. It appears to be generally wider in lion and *Felis spelæa* than in tiger. Its width in the skull figured in Pl. X is 0·55, in a lion's skull of our own 0·54 inch.

The ethmoidal surface follows for the most part the form of the thin optic plate. The great thickness, however, of the coronal plate makes the roof of the cavity underneath convex longitudinally. The inter-frontal suture is strengthened below by a long spine projecting far into the nasal cavity, and attached to the vertical plate of the ethmoid. It is called the "nasal spine of the frontal," and divides the posterior part of the cavity into two large hollows, which receive the upper and posterior masses of the ethmoidal convolutions. The walls also of the optic plates are ridged longitudinally (see Pl. VIII). These cavities for the reception of the ethmoid are called the "ethmoidal sinuses of the frontal." The arrangement of the frontal, cranial, and optic, plates is such as to form opposite the supra-orbital process two large pear-shaped chambers, connected by small orifices with the ethmoidal cavities described above. These chambers are the frontal sinuses, separated from each other by the nasal spine.

This massive bone affords points of insertion to many important muscles, the largest of which is the great temporal or crotaphite, the antero-external branch of which rises

from the temporal ridge and posterior border of the supra-orbital process. The anterior part of the third and internal branch springs from the lower portion of the temporal fossa, while the posterior takes its origin from the parietal. Several muscles of the eye, namely, those for the rotation and general movement of the eyeball and the eyelids, also have their point d'appui in this part of the skull. The rectus internus or "grand adducteur" and "petit adducteur" of Straus-Durckheim, equivalent to a portion of the choanoid, rise near the orbito-sphenoidal suture. Above them are the roots of the rectus superior or "grand élévateur" and the "petit élévateur" of the same author, equivalent to another portion of the choanoid; and above these is that of the elevator of the upper eyelid. The palpebral, in addition to its other attachments to the maxillary, the lachrymal, and the fronto-malar ligament, springs also from the extremity of the supra-orbital process. Of the muscles of the ear, the "sourcilio-scutien" of Straus-Durckheim does not appear to be represented in man. It rises within the orbit, and performs the function of bringing forward the ear. Another muscle taking part in the same office, the fronto-auricularis, springs from the superciliary ridge. The scutiform cartilage is attached by means of the temporal aponeurosis to the anterior part of the temporal fossa. To it are attached muscles which control the motions of the ear. In the temporal aponeurosis a considerable portion of the great temporal muscles takes its origin, besides other muscles of no particular importance.

§ 18. *Nasals* (Pls. VII, X, No. 15).—The nasals in Felis are two thin plates of bone forming the anterior part of the roof of the skull. They are scalene-triangular in form, deeply curved transversely, nearly straight longitudinally, and united somewhat loosely by a long, straight, deep suture. They form the upper covering of the nostrils, being articulated behind to the frontals by a deep overlap, as we have described in our description of that bone, laterally to the maxillaries by a suture, the inner edge of which projects into the nasal cavity, forming a sharp ridge for the attachment of the anterior branch of the ethmoid. They are also articulated for a short distance to the inner and upper edges of the nasal processes of the inter-maxillaries. In the living animal the anterior edges of the bones afford attachment to the epirhine cartilage anteriorly, and to the pararhine externally, which form the outer portions of the nostrils.

The nasals appear generally to be stouter and more decidedly triangular and flatter posteriorly in the lion than the tiger, being depressed so as to form a median groove at the symphysis in the latter animal.[1] M. de Blainville[2] also notes as differences in the latter animal as compared with the lion—"La déclivité des os du nez, qui sont aussi plus étroits, plus allongés, plus parallelogramiques, le lobe inférieur de leur bord libre étant plus prolongé et plus detaché:" we have found, however, that the variations are so great in these

[1] Owen, 'Proceed. Zool. Soc.,' 1834.
[2] 'Ost. Felis,' p. 28.

points in a large series of leonine and tigrine skulls that we cannot consider them of specific value.

The frontal[1] muscle is inserted into the lower extremity of these bones: it passes upwards to join the fronto-auricular muscle, another branch forming a part of the elevator of the nose and upper lip.

These bones are not perfect in any skull of *Felis spelæa* which we have seen, being almost entirely absent from the British specimens, and in that from Sundwig presenting only sufficient to show the flatness of the posterior portion which is characteristic of lion.

[1] Straus-Durckheim, op. cit., vol. ii, p. 187.

§19. Measurements of Skull of Felis spelæa, Lion, and Tiger.	*Felis spelæa.*				*Lion.*				*Tiger.*				
	Sandford Hill Cave.	Hutton Cave.	Sundwig, British Museum.	Sandford Hill Cave, No. 2.	Oxford, 692 *a*, (large).	Oxford, Cape, (small).	British Museum, Gambia, 112*d*.	W. A. S. (rather large).	Oxford Museum, Capt. Thornhill, (large).	Oxford Museum, Himalayah, (small).	British Museum, Nepaul, 114 c.	W. A. S. (large).	Taunton Museum, Capt. Speke, Oude, (large).
1. Basal length (median)	13·00[1]	11·55	10·45	...	11·78	9·37	11·95	12·00	10·75	9·40	10·75	11·50	11·00
2. Zygomatic width	9·10[2]	9·20	...	...	10·14	7·38	9·05	10·08	8·90	7·15	9·20	9·42	9·38
3. Height from palate to supra-orbital	4·85	4·24	4·80	...	4·12	3·49	4·05	4·79	4·20	3·70	4·10	4·65	4·39
4. Extreme length	...	13·22	11·95[6]	...	13·62	10·65	13·81	13·60	13·17	10·60	13·65	14·22	13·49
5. Sagittal length of parietal	...	4·00	3·42	...	3·80	2·51[7]	3·63	4·60	3·00[7]	3·00[7]	4·20	4·50	5·13
6. Median frontal length	4·60	4·53	4·12	...	3·95	3·31	4·20	4·00	3·95	3·76	4·23	4·25	3·76
7. Median nasal length	...	...	...	...	3·15	2·38	3·35	2·70	3·62	3·16	4·05	3·62	3·65
8. Maximum parietal width	3·63	3·45	3·30	...	3·40	3·07	3·63	3·10	3·22	3·05	3·43	3·80	3·05
9. Maximum frontal width	...	4·47	3·75	...	4·53	3·40	4·50	4·87	3·70	3·25	3·37	3·86	3·50
10. Width at parieto-frontal suture	2·70	2·98	2·48	...	2·50	2·36	2·45	2·60	3·32	2·75	2·85	2·75	2·90
11. Minimum width at orbits	3·20	2·66	2·50	...	2·93	2·15	2·75	2·87	2·27	2·16	2·27	2·68	2·80
12. Maximum width of nasals	...	2·54[4]	2·25[4]	2·90[4]	2·45	2·02	2·48	2·45	2·17	1·77	2·16	2·13	2·25
13. Malar width at maxillary suture	6·36	6·00	5·87	7·00	6·70	5·46	6·24	6·75	5·64	4·81	6·14	6·44	6·13
14. Infra-orbital width of maxillaries	3·98	3·86	3·57	4·12	3·51	3·05	3·95	3·90	3·40	2·50	3·28	3·50	3·40
15. Width of maxillaries above PM2	...	3·85	3·88	4·75	4·26	3·39	3·92	3·76	3·60	2·88	3·50	3·64	3·75
16. Maximum width of premaxillaries	...	2·80	2·75	3·67	3·20	2·38	2·88	3·00	2·85	2·12	2·51	2·70	2·65
17. Incisal width	...	1·80	1·79	2·15	1·78	1·55	1·90	2·10	1·63	1·60	1·88	1·75	1·64
18. Paroccipital width	...	4·27	...	...	4·28	3·68	4·47	4·25	3·90	3·37	4·00	4·10	4·34
19. Occipital height	...	3·85	...	...	4·00	3·08	3·81	4·00	4·00	3·08	4·29	4·55	4·50
20. Mastoidal width	5·50[3]	5·29	4·88	...	5·14	4·03	5·38	5·33	4·82	4·25	4·50	5·16	5·10
21. Maximum tympanic width	3·72	3·66	3·62	...	4·25	3·45	4·13	3·75	3·61	3·15	3·57	3·72	3·75
22. Minimum between tympanics	1·30	1·29	1·50	...	0·95	1·11	1·20	1·25	1·12	1·06	1·10	1·20	1·18
23. From paroccipital to anterior border of articular	...	3·20	...	...	2·87	2·40	3·00	2·85	3·08	2·30	2·88	3·05	2·95
24. Glenoid cavity to alveolar border	3·90	3·54	3·35	...	3·65	2·62	3·80	3·50	2·75	2·75	3·78	3·48	3·40
25. Maximum internal width of zygoma	2·90[8]	3·10	...	...	3·50	1·10	3·26	3·60	3·35	2·50	3·75	3·40	3·62
26. Minimum width of posterior nares	...	...	1·32	...	1·70	1·77	1·60	1·45	1·32	1·06	1·40	1·35	1·40
27. Minimum palatal width	...	...	1·78	...	1·87	2·30	2·15	2·20	1·95	1·62	1·78	1·85	1·75

28. Maximum width, palatal bones	...	3·50	2·25	...	4·30	4·20	3·85	3·90	3·23	2·50	2·36	3·60	3·23
29. Width of maxillaries at PM4 (internal)	5·12	5·00	4·25	6·00	5·20	5·13	4·50	5·08	4·42	3·50	4·25	4·40	4·54
30. Width at premaxillary suture	...	2·30	2·00	2·75	2·40	1·78	2·15	2·45	2·04	1·68	1·95	2·10	1·94
31. Median length of entire palate	...	...	5·75	...	6·18	5·13	6·63	6·20	5·88	5·10	5·63	6·00	6·13
32. From alveolar border of MI to external edge of premaxillary	...	5·29	5·00	6·88	6·00	5·08	5·72	5·70	5·00	4·50	5·34	5·28	5·28
33. Lacrymal to infra-orbital process	2·24	2·02	...	...	1·98	1·74	2·00	2·10	1·85	1·58	1·87	1·90	1·90
34. Maximum from malar to supra-orbital process	2·90	2·64	2·50	...	2·72	2·11	2·50	2·64	2·80	2·27	2·87	2·65	2·70
35. Thickness of arch of infra-orbital foramen	0·63	0·60	0·55	0·85	0·45	0·28	0·58	0·52	0·64	0·50	0·58	0·57	0·50
36. Maximum width of anterior nares	...	2·20	1·75	2·70	2·05	1·50	2·10	2·25	1·75	1·46	1·75	1·85	1·90
37. From posterior palatal foramen to posterior edge of palate	0·60	0·55	0·56	0·66	0·77	0·48	0·75	0·65	1·23	0·75	0·92	1·12	0·90
38. Temporal length of frontals[9]	2·24	2·20	2·15	...	2·00	1·50	2·25	1·85	3·00	2·00	3·12	2·92	2·52

[1] The length of the whole skull is estimated by placing it on the jaws that belong to it; thirteen inches is probably somewhat below the true length.

[2] 9·10 inches is probably somewhat below the truth, as the bones have been slightly displaced in setting up the skull.

[3] Approximate, for the same reason as the last.

[4] Estimated from the intermaxillaries.

[6] The summit of the supra-occipital is slightly broken.

[7] Exclusive of the Wormian.

[8] 2·90 is probably somewhat below the truth, owing to the reason stated in the second note.

[9] We give measurement "38" in Lions and Tigers of different sizes from specimens in the British Museum: thus—

Lions.		*Tigers.*	
Very large	2·25	Small	2·78
Large	2·18	,,	2·65
Small	1·90	,,	2·62
Very small	1·50	,,	2·62
Small	1·78	Large	3·12
Small and young	1·75	,,	3·00
Large old animal	1·84	,,	3·15
		Small	2·15

The last Tiger is a very small animal, which has many points of approximation to the Lion, but is Tigrine on the whole. The above were selected from a large number as fairly representative of the different varieties of form and size of the two animals.

§ 20. *Summary.*—We have compared each bone of the head in detail, in order that the resemblances and the differences between Lion, Tiger, and *Felis spelæa,* should be thoroughly, as far as lay in our power, examined and exhausted. We subjoin a summary of our observations of the characters, dividing them into those we consider constant, and those that we have found to be mere tendencies.

Professor Owen, in the 'Proceedings of the Zoological Society,' January, 1834, enumerates the first of the three following points:—1. The prolongation backwards of the frontal (nasal) processes of the maxillary bones in the lion, at least as far back as the transverse line passing through the fronto-nasal articulation; whereas, in the tiger, the former always falls short of the latter by at least one-third of an inch. In the tiger, also, the frontal processes of the maxillary are truncated, in the lion pointed. 2. The form of the nasal aperture, which we describe somewhat differently from the mode of expression adopted by Professor Owen; this difference is also noted by M. de Blainville. 3. The greater flatness of the frontal ends of the nasal bones in lion, which in the tiger are bent downwards, so as to form a median depression at the symphysis. 4. Baron Cuvier points out the greater flatness, and generally speaking the greater width of the inter-orbital space of the frontal bones in the lion, an observation which is confirmed by Professor Owen; the latter, however, does not consider this character as constant. We consider that, with the qualifications expressed in our description of the frontals, the skulls of the two species may be distinguished by this character alone. An examination of a very large series of feline skulls has convinced us, that these four points are strictly typical, and we have always been able to distinguish the skulls of lion or tiger by any one of them taken by itself. We have also remarked the following points: 5. The smaller temporal length of the frontals, and consequent forward position of the parietal suture, and backward position of the post-orbital process in the lion as compared with the tiger. This arrangement causes the leonine skull, when looked at from above, to assume what may be readily understood as a short-waisted aspect in contradistinction to the long waisted aspect of the tigrine. It also causes the great extension of the sagittal crest on the frontals in the adult tiger compared with its shortness in the lion. Baron Cuvier appears to have recognised this difference, though he expresses it very differently. 6. The comparatively shorter space between the posterior palatal foramen and the orbital edge of the palate in lion. This measurement must always be compared with the basal length of the skull to arrive at a true conclusion. 7. The presence of the ramal process pointed out in Chapter I is an essential character of the lion. 8. To these perhaps may be added the presence of the tentorial spine in the tiger and its absence in the lion.

We have also observed that the following tendencies are evinced by the two animals, which are not sufficiently constant to be regarded in the light of absolute specific characters. 1. Baron Cuvier mentions the "serpentine form of the profile" as peculiar to the tiger, the more rectilinear profile to the lion, and the gentle curve to *Felis spelæa.* We cannot admit that any of these characters are of specific value. 2. M. de Blainville's distinc-

tion between the two animals already described in our section on the palatals we are also unable to admit. 3. The occipital portion of the skull is often narrower and more sigmoid in the tiger than in the lion. 4. The posterior nares are also generally narrower. 5. This observation may also be made concerning the basi-occipital and basi-sphenoid. 6. The size of the sub-orbital foramen and thickness of the arch dividing it from the orbit, which is greater in tiger and *Felis spelæa* than in lion, are not characters of great importance, for both are very variable in the latter animal: in the Asiatic lion the foramen is sometimes double. 7. The depth of the zygomatic arch insisted on by several anatomists we find so variable, that we cannot regard it as any guide whatever in the determination of feline skulls.

We can now proceed to the application of these characters to the settlement of the question of the leonine or the tigrine affinities of *Felis spelæa*. The smaller Taunton skull which we figure, and which probably from the size of the canines was that of a female, so closely resembles that of a lion of average size, that we cannot detect any difference whatever. It differs from every tiger's skull which has passed through our hands, not only in the characters, but also in the tendencies, with the exception only of the size of the sub-orbital foramen and the thickness of the arch separating it from the orbit. The smaller skull also from Sundwig, though it shows an approach to the tiger in some of its tendencies, in all the characters is decidedly leonine. Besides these spelæan skulls, there are the larger and less perfect ones. We have shown that these differ in no respect except size, from the average leonine skull; while, whenever those parts remain in which constant differences may be looked for, they differ invariably from tiger and agree with lion. With regard to differences which have been cited by other naturalists, we have not been able to detect the "museau renflé" of the French anatomists in either the English or German specimens. In comparing animals of the same size, the muzzle in no respect differs from that of the lion; but we have observed, that the shortness and width of the muzzle varies directly in proportion to the size of the animal. We have had no means of examining the pterygoid processes or the anterior ends of the nasals in *Felis spelæa*, and we cannot consequently apply M. de Blainville's distinctions founded on these parts to that animal.

With regard to size, the measurements given by Cuvier of the largest skull of lion passed through his hands closely agree with those of the most perfect of the large Taunton specimens. The maxillaries figured in Pl. XI are somewhat larger, but they differ in no other respects from those belonging to the more perfect skulls. Aristotle, in his 'Natural History,' gives the large size of the Thessalian lion as a characteristic. In Pleistocene times, before man had increased and multiplied on the earth, the abundance of food and the great range were more favorable to the more powerful and larger breeds of animals, while now the necessity for agility and concealment, caused by man's disturbing influence in the animal world, would favour the smaller. We cannot therefore expect the largest of

the living lions to equal in size the largest of the cave lions, because the conditions of their existence are different.

The difference in size between the largest cave lion on the one hand, and the average living lion on the other, is not so great as between the largest Barbary lion and the smallest Asiatic. We therefore consider that there is no ground for regarding the largest and smallest individuals of *Felis spelæa* as distinct species; and we find every reason to consider them both as undistinguishable from the lion, and as distinguishable in all respects from the tiger, so far as relates to crania.

The numbers used in the Pls. VI to XI, to denote the separate bones, are those given by Professor Owen in his 'Homology of the Vertebrate Skeleton.' The letters are as follows:—

a. Foramen lacerum posterius.
b. Condylian fossa.
c. Para-mastoid fossa.
d. Para-mastoid tubercle.
e. Splenial fossa.
f. Vidian foramen.
g. Foramen ovale.
h. Sectorial fossa.
i. Frontal process.
j. Posterior palatine foramen.
k. Naso-palatine, or anterior palatine foramen.
l. Mastoidal process.
m. Meatus auditorius externus.
n. Outer surface of tympanic chamber.
o. Line of articulation of squamosal with mastoid.
p. Glenoid cavity.
q. Squamosal ridge.
r. Squamosal pit (see squamosal, § 11, p. 3).
s. Sub-orbital process.
t. Supra-orbital process.
u. Palpebral tubercle.
v. Lachrymal foramen.
w. Naso-maxillary process.

CHAPTER VII.

Pls. I, VI, VIII, XI, XII, XIII.

CONTENTS.

§ 1. *Introduction. The Elements of the Teeth. The Dental Formula.*
§ 2. *Permanent Teeth.*
a. Upper.
β. Lower.
§ 3. *Milk Teeth.*
a. Upper.
β. Lower.
§ 4. *Measurements.*

§ 1. *Introduction.—The Elements of the Teeth.*—The large numbers of the teeth from the caves and river-deposits of Great Britain afford ample materials for working out the whole of the dentition of *Felis spelæa*, with the exception of some of the milk incisors. All the specimens we figure are from the bone-caves of Somerset, with the exception of a large upper canine and two small incisors, from a cave in Gower.

The teeth of *Felis spelæa* consist of the same elements variously modified according to the functions each tooth has to perform. The primary element is a cone for piercing flesh, the form of the whole tooth being modified, as the case may require, by the addition of one or more parts. The permanent canines are examples of the first form (Pl. XI, figs. 1, 5, 6, 7; Pl. XII, figs. 4, 5, 6), in which the "primary" cone (*a*) represents the whole of the crown, the secondary cusps being reduced to all but obsolete tubercles; while in the milk canine of the lower jaw (Pl. XIII, fig. 7), it is modified by the addition of a "secondary" internal or *anterior* cusp (*b*). In the lower incisors (Pl. XII, figs. 1, 2, 3), it is modified by an outer or *posterior* cusp (*c*). In premolar 3 (Pl. XI, figs. 9, 10, 11) of the upper jaw, we find the primary cone (*a*) with large anterior and posterior "secondary" cusps (*b* and *c*), and a small posterior "accessory" (*e*). On premolar 4 (Pl. XI, figs. 1, 12, 13) of the same jaw, (*a*, *b*, and *c*) are modified for a sectorial pur-

pose, and a minute anterior accessory (*d*) is added, which, in the milk molar 3 of the same jaw (Pl. XIII, figs. 2, 6), becomes an important portion of the tooth. In both these teeth there is in addition an internal projecting "tubercular" cusp (*f*), the base of which is connected with the summit of (*a*) by a well marked buttress or rounded ridge, and with the summit of (*b*) by a similar buttress with a sharper edge. This "tubercle" (*f*) is represented in the upper incisors by small posterior or *internal* cusps. We find that in all cases the anterior fang of the tooth, which we will call (*a*), is concerned in the support of (*a*) as well as (*b*) and (*d*); whereas the second outer fang, reckoning backwards, supports the remainder of (*a*), together with (*c*) and (*e*), when they exist; while the remainder, whether one or more, &c., support (*f*), and the cusps serially connected with it. In one-fanged teeth, the relative size of (*a*) appears to absorb the whole fang (*a*), the cusps being of perfectly subordinate importance. It may be further remarked, that *a* has invariably a double cutting edge anterior and posterior to the more or less pointed summit, that the edge of (*b*) and (*c*) extend only in the cases where (*d*) and (*e*) exist into the clefts which separate these cusps from (*b*) and (*c*), but that when either of them terminate the tooth, the edge merges into the more or less rounded anterior or posterior surface. If we apply these rules to the true molar of the lower jaw (Pl. XII, figs. 13, 14, 15), we shall see that the posterior blade is *a* slightly inclined backwards, and that the anterior is (*b*), being precisely similar in form, though much enlarged, to the same cusp in $\overline{\text{PM } 4}$.

The only remaining tooth, which offers any modification different to those noticed above, is the small true molar of the upper jaw. The extremely slight definition of the cusps of this tooth, in the genus *Felis,* would render the determination of them a matter of some difficulty, were it not for the light thrown on their arrangement by other genera. It will be seen, that in the unworn tooth in this genus, there are three minute elevations on the posterior border of the tooth separated from each other by slight depressions; slight ridges from the posterior bases of the two inner cusps, pass round the back of the tooth towards the outer, while a similar ridge is seen to pass round the fore part of the tooth from the summit of the middle to the summit of the outer cusp, on comparing this with that of the corresponding tooth of *Canis,* say the jackal, we immediately see that these minute elevations represent three well defined and separated cusps in the latter tooth; the outer cusp is immediately seen to represent (*a*), the middle one (*f*), and the inner, a cusp with which we have hitherto not met, which assumes a very considerable development in other genera, and which we call (*g*.)

This system of assigning names and letters, and of analysing each tooth, may, perhaps, seem the offspring of fancy; but we find it to be of great value, both in the accurate determination of the tooth of the Carnivora, and especially in affording a means of exact correlation of the dentition of the recent with the extinct forms, or in other words, of testing, by means of the analysis of the supposed serial development of the teeth, the doctrine of "ordinary succession with modification."

The dental formula of *Felis spelæa* is that of the restricted family *Felidæ;*

$$\frac{\text{DI. 1, 2, 3. DC. DM. 2, 3, 4. I. 1, 2, 3. C. PM. 2, 3, 4. MI.}}{\text{DI. 1, 2, 3, DC. DM. 3, 4. I. 1, 2, 3. C. PM. 3, 4. MI.}}\quad \text{D. 26.}\quad \text{P. 28.}$$

$\underline{\text{PM 2}}$ is often wanting. $\overline{\text{PM 2}}$, though often found in other species, has not occurred in *Felis spelæa.*

§ 2 *a.* *Upper Permanent Dentition.* Pls. VI, VIII, XI.—The upper permanent teeth of *Felis spelæa* present no important differences as compared with those of lion and tiger.

Incisors. Pl. XI, figs. 1, 2, 3, 4.—The small incisors 1 and 2 are so closely alike, that the inner (Pl. XI, figs. 1, 2) is only to be known from the outer (figs. 1, 3) by the possession of a shorter crown, and by its smaller size. Each has a simple fang compressed parallel to the median line, and nearly straight: the crown of each is somewhat strongly recurved and traversed by a transverse ridge, so that it presents a cutting edge. On the posterior or *internal* base rise two small lobes (*f*), which are usually more evident on $\underline{\text{I 2}}$ than on $\underline{\text{I 1}}$. The third (figs. 4, 4′, 4″), as in all the Carnivora, is larger, and more caniniform than the other two, and is implanted by a stout subcylindrical fang. In the unworn state, it presents a recurved cone, springing from a base oval in outline, but flatter internally than externally, and transversed posteriorly by a broad and, in part, deep groove, passing obliquely from the base downwards and inwards, the tooth being held in the natural position, which is representative of that on $\underline{\text{I 1}}$ and $\underline{2}$, and marks off a corresponding small tubercle or cusp (*f*) on the inner posterior or *internal* side. The cingulum is slightly or moderately developed. We are able to figure a perfectly unworn tooth from Bleadon Cave, which had belonged to so young an animal that the fang has never been ossified. This tooth is easily differentiated from the corresponding tooth of the hyæna, by the more slender and slightly more curved form, by the smaller breadth and greater depth of the posterior groove, by the consequently greater size of the cusp (*f*), as also in young specimens, by the perfect smoothness of the enamel. The canines of the glutton with which this tooth is sometimes compared, are essentially different in form, and are also far more slender, and their enamel surface is much rougher than even in the teeth of hyæna.

Canines (Pl. XI, figs. 1, 5, 6, 7).—The canines of the larger specimens of *Felis spelæa* were truly formidable weapons, and exceeded in size those of any adult lion or tiger we know of. The largest we have seen is from Crayford, in the Thames Valley. It measures 6·80 inches in length, the point being somewhat abraded. This somewhat exceeds the large specimen figured by De Blainville.[1] It unfortunately did not come into our hands until our plate of the dentition was finished, in which we had figured as the largest British specimen one about the size of the French tooth, from Wookey

[1] 'Ost. Felis,' pl. xv.

Hyæna-den. This has the point and the inner side a little abraded by the wear of the lower canine. We figure a second specimen (Pl. XI, fig. 5) found in Ravenscliff Cave, Gower, by Colonel Wood, to whose courtesy we are much indebted for the loan of this specimen, as well as of the incisors $\underline{1}$ and $\underline{2}$, for the purposes of this work. This specimen is smaller than the last, and may be considered as a good example of the average size from the large form of the animal. Those figured in the under view of the maxillaries (fig. 1) are about the same size. They are slightly restored at the apices, which are a little splintered, but as sufficient of the points of the teeth remained to show that they were unworn, and the restoration was most carefully copied from exactly similar teeth, it is probable that it is perfectly exact. We have also figured specimens of the smaller form, which occurs in all the deposits which produce the larger, and were probably the canines of females (Pl. VI, VIII, and XI, fig. 7). At the time the plate was lithographed the last specimen was the smallest we had met with. We have, however, lately seen the teeth which were referred to, at p. xxi of the "Introduction," as probably those of *Felis antiqua,* on the authority of drawings shown us by Colonel Wood. The examination, however, of the teeth themselves, proves that they differ from those of that animal, and of its existing representative *Felis pardus,* in precisely the same respects, except size, as do ordinary canines of *Felis spelæa,* although they are very slightly larger than those of the former animal. We must therefore consider them as abnormally small specimens of teeth of *F. spelæa,* unless they afford the only known traces of another species. The great variations in size are given in the Table of Measurements of the Teeth.

The long recurved conical crown of the tooth (*a*) is supported by a strong sub-cylindrical fang, truncated at the base, that extends in old animals further into the maxillary than the suborbital foramen. The inner surface of the crown is somewhat flattened, and bounded intero-anteriorly and posteriorly by two sharp ridges passing from the apex to the base. In the unworn tooth the anterior of these is very slightly, and the posterior strongly serrated. This is also the case in other larger Feles, and corresponds with the similar character which is more highly developed in *Machairodus.* The intero-anterior ridge ends in a small basal tubercle (*b*): each of the external and internal triangular areas defined by their ridges and the base of the crown are traversed by two longitudinal furrows (*sillons*), of which the anterior is the deeper. The external surface of the crown is highly convex. The fang is considerably thickened in old age by a deposit of cement (fig. 6). The external contour of the whole tooth is a simple convex curve; that of the internal, in the old animal (fig. 6), presents a double curvature, whereas in the young (fig. 5) it forms a very obtuse angle with a slight bulge at the base of the crown. The anterior aspect is slightly sigmoid, the fang bending slightly outwards, and the conical point inwards.

The canines are separated from the incisive border by the canine fossa, and by a small diastema of very variable extent from the first of the premolar series.

Premolar 2. (Pls. VI, VIII, XI, fig. 8).—We have seen one specimen of the larger, and two of the smaller variety of Premolar 2 of *Felis spelæa*. The two former are in the smaller skull of which we have given a figure, and the latter is in a fragment of a jaw from Bleadon, which also retains a part of PM 3. The partially divided alveolus in the upper jaw, which we figure in Pl. XI, fig. 1, shows that the tooth had a tendency to become fanged, as generally in the panther. But the examination of other specimens of *Felis spelæa*, and of a large series of skulls of lion and tiger, shows that this tendency was not constant in either of these animals. The tooth is frequently entirely wanting, particularly in small specimens, in all three species. The crown consists of an obtuse central cone (*a*), traversed by a median ridge, the posterior portion of which becomes worn in old age (Pl. VIII). The contour is from nearly circular to oval, the two-fanged specimens being more oval than the monofanged. The fang in the smaller form is nearly straight, cylindrical, and tapering. It is separated by a small diastema from the next tooth.

Premolar 3. (Pls. VI, VIII, XI, figs. 1, 9, 10, 11).—The crown of this tooth consists of a stout primary cone inclined slightly backwards and inwards (*a*), with a secondary cusp (*b*) on the antero-internal aspect, and the secondary and accessory cusps behind (*c*), (*e*); each of these is divided from its fellow by a cleft, and is traversed by a sharp ridge that passes over the principal cone and gives the whole tooth a trenchant character. This ridge turns inwards as it passes from the apex of the tooth to the anterior cusp (*b*), by which character the upper tooth is distinguished from premolar 4 in the lower jaw. Occasionally, a minute tubercle (*d*) appears on the anterior surface of (*b*). The inner surface supported by the posterior fang is slightly flattened. The fangs are two, divaricate and subcylindrical; the cingulum is very stout. The tooth varies much in size in different individuals, and sometimes, as in fig. 11, the secondary cusp (*b*) all but disappears. A strong bulge of the cingulum on the internal base of (*a*) occurs in many teeth of *F. spelæa* (fig. 1), from which ascends a strong buttress to the summit (*a*). This appears to be an indication of the tubercle (*f*) which assumes much larger proportions in PM 4. The extreme variations of size are shown in our plate; the smallest belongs to the same jaw as the smallest canine which we have figured. The only tooth that by any chance could be confounded with this is that of *Hyæna spelæa*. In the latter, however, the principal cone is higher, more decidely conical, and stouter; the posterior cusp is wanting; the cingulum is far more developed, and the sectorial character is exchanged for a bluntly pointed form, adapted for crushing rather than for cutting and tearing.

Premolar 4. (Pls. VI, VIII, XI, figs. 1, 12, 13).—This tooth may be described generally as consisting of two portions, the first, the tubercular set internally at right angles to the second, the two blades which compose the sectorial or trenchant portion of the tooth. The tubercular consists of a stout conical "secondary" cusp (*b*), occupying the antero-external angle of the tooth, and separated by a cleft from the anterior blade, and the tubercle (*f*) supported by the small inner subcylindrical fang, and which, though always present, is sometimes reduced to a minimum. This small and uncertain development contrasts

strongly with the large size of the corresponding tubercle of *Hyæna spelæa*. The anterior blade which forms the primary cone of the tooth (*a*) is the higher. A small rounded ridge passes from its summit to the tubercle (*f*). Posteriorly, its trenchant edge declines in height to the point where it is divided by a cleft from the posterior blade (*c*). The latter forms a trenchant waved horizontal edge, situated at an angle to the blade (*a*) which is very obtuse externally; below the cleft, the external side is hollowed out, so that the surface of the crown at this point is horizontal. The internal surface of the tooth is flattened from the tubercle (*f*) backwards, and is at a moderately early age worn away by the friction of $\overline{\text{M 1}}$. A tooth in this condition is represented in fig. 13. The cingulum is well developed, forming anteriorly, in most of the larger specimens, a well-developed cusp on the outer edge of the cusp (*b*); this may be taken as the rudiment of an "accessory" cusp (*d*), which assumes much larger proportions in $\underline{\text{DM 3}}$ of *Felis*. Half the cone (*a*) and the whole of (*c*) are supported by a fang of flattened oval section, and triangular or trapezoidal in outline, and the other half of (*a*), and (*b*), and (*d*), by a smaller one, subcylindrical, and nearly straight, diverging at a considerable angle from the first, and, as before stated, the tubercle (*f*) by a still smaller fang, similar, and of equal length, and generally connate with the second, and sometimes united to it through its whole length. The extreme variations in size that we have met with are shown in our plates of the smaller skull (Pls. VI and VIII, and in Pl. XI, figs. 1, 12, 13).

Molar 1. (Fig. 14).—We have seenbut one specimen of the true molar of *Felis spelæa*. It is from Bleadon. It is elliptical in outline, the long axis of the ellipse being transverse; it is supported by two connate and confluent fangs; but we have met with alveoli which indicate that they are sometimes connate only. This specimen is much worn, as is generally the case with the corresponding recent teeth. We do not, therefore, give a more particular account of the tooth than that given in our Introduction to the Dentition (p. 66); but refer to our figures, which give the general appearance. The alveoli are represented in Pl. XI, fig. 1, and in Pl. VIII, at the postero-internal angle of $\underline{\text{PM 4}}$.

A comparison of the upper permanent dentition of *F. spelæa* with that of lion and tiger, has compelled us to infer that there are no points of difference of specific value between them; the largest teeth of *F. spelæa* are larger than those of the largest living lions and tigers; but they form a regularly graduated series from the smallest to the largest form. The smallest teeth of *F. spelæa*, indeed, are far smaller than the average of the living animals. Those already alluded to from the Gower cavern are only to be matched by the very smallest leonine and tigrine teeth. Dr. Schmerling long since determined that the character of the absence of $\underline{\text{PM 2}}$, depended on by MM. Goldfuss and Cuvier as characteristic of *Felis spelæa*, was a simple variation, which is also, as we have before stated, common to lion, tiger, and other *Feles*.

§ 2 β. *Permanent Dentition of Lower Jaw* (Pls. I, VI, and XII).—The dentition of

the lower jaw in *Felis spelæa* precisely resembles that of the lion, except in the size of the larger specimens. There appears to be a very slight difference in the form of $\overline{\mathrm{PM}\,3}$ in most specimens of tiger.

Incisors. (Pl. XII, fig. 1, 2).—$\overline{\mathrm{I}\,1}$ and $\dot{2}$ agree in all respects save that of size, the latter being the larger in every dimension, though not to the extent indicated in our plate; $\overline{\mathrm{I}\,1}$, being the tooth of a much smaller animal than that to which $\overline{\mathrm{I}\,2}$ and $\bar{3}$ belonged. The crown (*a*) is conical in the unworn tooth, and slightly recurved; it is hollowed behind, and the base of the hollow is filled by a small lobe to which a slight ridge descends from the apex; and, on the outer (*posterior*) side is a small cleft which marks off a cusp (*c*) from the trenchant edge of the tooth. The fang is long and slightly recurved, subcylindrical, but compressed. $\overline{\mathrm{I}\,3}$ (fig. 3) is characterised by the larger size, the higher crown the greater distinctness of the lateral cusp, and the greater curvature of the fang. The incisors both of the upper and lower jaw can be distinguished from those of the hyæna, by the shorter crown, the smoothness of the enamel, and by the greater length of the fang. The incisors of the wolf have still longer crowns, and shorter and more slender fangs. The incisors of the bear are less curved, and more conical in the crown; and both fang and crown are stouter. We know of no other fossil teeth that can be confounded with the incisors of *Felis spelæa.*

Canines. (Pl. I, VI, XII, figs. 4, 5, 6).—The lower canines are differentiated from the upper by the more decidedly sigmoid curvature of their anterior aspect, their somewhat smaller size, and the presence of but one groove or "sillon" on the exterior of the crown. The crown is shorter, stouter, and more curved, and the internal triangular area marked off by the sectorial ridges is more distinctly marked, and smaller, owing to the more backward position of the anterior ridge, which ends near the cingulum in a small but well-marked tubercle. Both ridges in the unworn tooth are strongly serrated. The cingulum is but feebly developed. The fang is hardly so massive as that in the upper jaw; it is somewhat compressed, and truncated at the base. The anterior outline of the whole tooth is a gentle convex curve, the posterior or internal is more or less slightly sigmoid. The postero-external face and point are often worn by the upper canine, sometimes to such an extent as almost to obliterate the external sillon. Similar remarks apply to the size of these canines (including those with regard to the small specimens from Ravens Cliff), as we made with reference to those of the upper jaw.

Premolars.—$\overline{\mathrm{PM}\,3}$ (Pls. I, VI, XII, figs. 7, 8, 9) of the lower jaw consists of a primary trenchant cone (*a*), accompanied by the anterior and posterior cusps (*b*) and (*c*). The cingulum is strongly developed posteriorly, forming a sharp edge interiorly. The crown is somewhat oval in section, and is supported by two fangs, connate, and nearly parallel in the larger, and highly divaricate in the smaller specimens, the posterior being the larger of the two. The anterior cusp (*b*) is obsolete in some specimens of both larger and smaller teeth. The anterior portion of the crown is always much smaller in transverse measurement than the posterior. In this last respect it resembles

the lion ; in the tiger, both anterior and posterior transverse measurements of the crown are nearly equal. The highly divaricate character of the fangs of the smaller teeth appears to be more characteristic of the recent lion than the more parallel arrangement of the larger, which we have found more prevalent in the jaguar. $\overline{\text{PM 2}}$ of the hyæna somewhat resembles this tooth. It is, however, much shorter and broader, the cone (*a*) is lower, the cusp (*b*) is generally obsolete, the cusp (*c*) is much larger, and the cingulum more developed.

Premolar 4. (Pls. I, VI, XII, figs. 10, 11, 12).—This tooth is built precisely on the same plan as $\overline{\text{PM 3}}$ with the exception that the cingulum is developed into a generally well-marked, posterior cusp (*e*), which, however, is occasionally obsolete, as in fig. 12. The primary cone (*a*) is also much higher and more trenchant, and (*b*) and (*c*) are much larger and more distinct. The cingulum is strongly marked, and developed, as in $\overline{\text{PM 3}}$, into a cutting edge posteriorly and internally. The section of the crown is oval; the posterior and anterior transverse measurements being nearly equal. The fangs are stout and long, cylindrical, slightly divaricate, and narrowed at the tips.

True molar 1. Pls. I, VI, XII, figs. 13, 14, 15.—The lower true molar consists of two trenchant blades; the cutting edges are inclined to each other at an angle, slightly obtuse on the lateral, and very open internally on the vertical aspect; externally the surface is convex, fitting the sectorial portion of the upper $\underline{\text{premolar 4}}$. Internally the surface is excavated in such a fashion that the trenchant edges are always preserved as the tooth is worn by $\overline{\text{PM 4}}$ as in fig. 13. The width of the excavation at the base of the cleft is one of the distinctions between this tooth and that of the hyæna. The posterior blade (*a*) is somewhat higher than the anterior (*b*); the former is traversed throughout by a trenchant edge, which leads posteriorly to the almost obsolete cusp (*c*), and anteriorly it is divided from the cusp (*b*) by a deep cleft. The trenchant edge of (*b*) is continued only on its posterior upper border, the cusp being rounded anteriorly. The cingulum is well developed, and on the inner surface there are three well-marked central tubercles, besides others which are variable in number and size. The cusp (*b*), and half the cone (*a*), are supported by a large anterior fang, a compressed oval in section, slightly recurved and trapezoidal in outline; the remainder of (*a*), with the little cusp (*c*), are supported by a posterior fang), small, short, straight, cylindrical, and slightly tapering.

We have already indicated the only difference we can perceive between lion and tiger in the dentition of the lower jaw, in our description of $\overline{\text{PM 3}}$. The variations, however, in this respect, in the corresponding teeth of the recent *Felidæ*, prove that it is a mere tendency and not a specific character.

The only fossil teeth of *Felis* we know of that can be compared with those of *Felis spelæa* are those of *Felis aphanista* of Dr. Kaup, from the Miocene of Darmstadt, and the *Felis arvernensis* of MM. Croizet and Jobert. The teeth of the former animal, among which may be reckoned the upper premolar 4, ascribed by Dr. Kaup to

F. prisca,[1] are not sufficiently well preserved to warrant an accurate comparison. $\overline{\text{PM 4}}$, however, appears comparatively smaller, and the cusps (*b*) and (*c*) are more nearly of the same size and shape than in *Felis spelæa*, and $\overline{\text{PM 3}}$ is proportionately much larger. It also closely resembles $\overline{\text{PM 4}}$ in shape, which is not the case in the more recent large *Feles*. Although in *Felis arvernensis*[2] $\overline{\text{M 1}}$ is nearly of the same size as in the smaller *Felis spelæa*, the summits of the blades are closer together, so that the tooth assumes a more pyramidal aspect, and the remainder of the dentition is proportionately of much smaller size. The species is considered doubtful by M. Gervais,[3] but he does not indicate its probable affinity. The distinctions between the teeth of *Felis* and *Machairodus* will be noticed in our description of the latter genus.

§ 3. *Milk dentition* (Pl. XIII).—The materials we have for describing the milk dentition of *Felis spelæa*, all obtained from the bone caves of Somerset, enable us to give the characters of all the teeth, except the upper incisors and the two inner incisors of the lower jaw.

The specimens we have examined are the following:

A left upper maxillary (Pl. XIII, fig. 1) that belonged to an animal of rather more than three months old, as far as we can estimate the age by a comparison with the skull of a lion's whelp in our own collection, which was about four months old when it died. It retains $\underline{\text{DM 3 and 4}}$, with the alveolus of $\underline{\text{DM 2}}$, while germs of $\underline{\text{premolars 3 and 4}}$ are imbedded in their alveoli in the substance of the bone. It was found in Hutton cave, in the Mendip. We also figure the anterior portion of a maxillary from Bleadon (fig. 2), which retains $\underline{\text{DC}}$ and $\underline{\text{DM 2}}$. The vertical aspect of the latter tooth is given in fig. 1″, in order to save space, and give, as far as possible, the natural arrangement of the milk molar dentition. We have a pair of maxillaries of a very young animal from Sandford Hill, one with $\underline{\text{DC}}$ and $\underline{\text{DM 3}}$, and the other with $\underline{\text{DM 3}}$; of this latter tooth we give a separate figure (fig. 6). We have also from Bleadon cave a crushed maxillary with $\underline{\text{DM 3}}$, and two other detached upper deciduous molars, 3. We are uncertain as to the exact locality whence came four upper canines, one of which we figure (fig. 5).

Of the lower jaw we have two nearly complete rami from Hutton, apparently belonging to the same animal as did the maxillary which we have figured. One of these, represented in fig. 3, possesses the deciduous molars 3 and 4, the fang of the deciduous canine, the alveoli of the deciduous incisors, and shows the germ of the true molar; the other has the fangs of the milk dentition and the germ of the molar. From the cave in Sandford Hill we have a pair of very young rami, which apparently belonged to the

[1] Kaup, 'Oss. Foss. de Darmstadt, Carnivora,' pl. ii, fig. 1, 16, 2.

[2] MM. Croizet et Jobert, 'Oss. Foss. du Puy de Dome,' pl. v, fig. 3.

[3] 'Zool. et Palæont. Françaises,' ed. 1859, p. 228.

same animal as the maxillaries above mentioned. The most perfect of these rami we figure with $\overline{\text{DC. DM 3 and 4}}$, (fig. 4); the other retains DC only. There is also a half ramus of a still younger animal, with $\overline{\text{DC}}$; and a $\overline{\text{DM 3}}$ of large size with very long fangs, of which we give a separate figure (fig. 8).

From Bleadon we have four more or less crushed rami of large size; one of which has $\overline{\text{DI. 3, DC. DM. 3 and 4}}$, the fangs of DI. 1 and 2, and the germs of $\overline{\text{I 1. C. and M 1}}$ visible. The third milk incisor of this jaw is that represented in the figure of the large ramus (fig. 3), for the sake of economising space. A second ramus has $\overline{\text{DC. DM 3 and 4}}$; two others fangs only, and germs of permanent dentition; a fifth has DM 3 and 4, and germ of C; a sixth, $\overline{\text{DM 3}}$; a seventh $\overline{\text{DM 4}}$. We are uncertain as to the locality whence were derived another ramus, with $\overline{\text{DM 3 and 4}}$; and three canines, the crown of one of which is represented in fig. 3, and the whole tooth in fig. 7. We know, however, that these teeth, as well as the upper canines, were from one or other of the Mendip caves. The whole of these specimens are in the Museum at Taunton.

We have met with notices of the occurrence of the fossil milk dentition of *Felis spelæa* in France and Germany.[1] MM. Marcel de Serres, Dubreuil, et Jeanjean have figured and described $\overline{\text{DM 3, DM 4, and DC}}$ of the lower jaw, and $\underline{\text{DM 3}}$ of the upper; the lower $\overline{\text{DM 3}}$ being wrongly described as "premiere fausse molaire." In Germany,[2] Professors Giebel and Heintz figure and describe a lower jaw, containing $\overline{\text{DC, DM3, and 4}}$. The whole of these teeth agree in every respect with those figured in our Pl. XIII.

§ 3 *a*. *Milk dentition of the upper jaw.*—Unfortunately we have met with no examples of the milk incisors of the upper jaw of *Felis spelæa;* but they probably differ in no respect, save size, from those of the lion. The milk upper canine $\underline{\text{DC}}$, (figs. 1, 1′, 8), somewhat resembles the lower permanent $\overline{\text{C}}$ in general form, but is more compressed on the intero-posterior side. The crown is traversed by two trenchant edges, the anterior of which is placed further forward than in $\overline{\text{C}}$; these circumscribe a nearly flat triangular area, and end basally in two small tubercles. This area presents, near the apex, two grooves or sillons, similar to those which are characteristic of the adult upper canines of *Felis;* but of which, on the external aspect, there is no trace in the deciduous tooth. The internal base of the fang is excavated, to afford room for the growth of the permanent canine.

Milk molar, 2. (Figs. 1″, 2, 2″.)—The small milk molar 2 is separated both from the canine and milk molar 3, by diastemata. It has a small cylindrical crown, consisting of a small central cusp, traversed by a low trenchant edge. It will be remembered that the above figures are all taken from the same tooth, in order to complete,

[1] 'Oss. Foss. de Luml. Viel.,' pl. vii, fig. 8, 9, 10, p. 111.

[2] 'Zeitschrift. für die Gesaminten Naturwissen schaften.,' vol. iv, 1854, p. 295, tab. vi.

as far as possible, in fig. 2, the appearance of the milk molar dentition in one maxillary. The tooth is supported by one small cylindrical and slightly tapering fang.

Milk molar, 3. (Figs. 1, 1′, 1″, 2, 2′, 6.)—This tooth, which is sectorial, is by far the largest of the series. The cone (*a*) of this tooth is central, compressed, rounded externally, and flattened internally; but a distinct buttress can be traced from the summit to the internal base, where a few minute prominences represent the tubercular cusp (*f*). It is furnished with sharp-cutting edges, anteriorly and posteriorly, the latter being nearly perpendicular, and separated from the long, horizontal, blade-like cusp (*c*), by a deep cleft; the latter, in the unworn tooth, has the appearance of being double, the trenchant edge being deeply waved, but the cleft, if any, is very slight; the tooth ends posteriorly in a much compressed but rounded lobe, formed by the cingulum; anteriorly the knife-like edge of (*a*) is inclined at an angle of about 45° to the horizontal line, and is divided from the cusp (*b*) by a cleft. The cusp (*b*) is of blade-like form, but short, and with a central point, from which descends obliquely in a backward direction a sharp-edged buttress to the tubercular (*f*), anteriorly this is again separated by another cleft from the "accessory" cusp (*d*), which is again of a short blade-like form, but rounded anteriorly. The summits of (*b, c, d*) are nearly in the same horizontal line, from which the cone (*a*) rises to a considerable height. They are so disposed that the trenchant edge they form is concave externally. The cingulum is strongly developed, and has two rows of minute raised dots on it externally, and one similar row internally. It is supported by two similar highly compressed trapezoidal divaricate fangs of flat oval section, the anterior supporting half (*a*), (*b*), and (*d*), and the posterior the rest of (*a*) and the whole of (*c*); a normal cylindrical internal fang supports the very minute representation of (*f*).

Milk molar, 4. (Figs. 1, 1′, 1″.)—The minute cusps and ridges which point out the true homologies of this tooth in *Felis* being easily worn, their determination is very difficult, except in the very young specimens. The crown is somewhat triangular in form, the longest side of the triangle forming the anterior border. The posterior angle forms a rounded lobe, on the summit of which is a minute cone, traversed by a sharp cutting ridge; this descends posteriorly to a minute cusp at the extremity of the angle, and anteriorly it turns outward, and terminates in the very young lion at a minute cleft, which separates it from a ridge forming the summit of another cusp, of the same shape as (*b*) in $\underline{\text{PM } 4}$ on the external angle of the tooth. The minute cone is the homologue of (*a*), and the small posterior cusp of (*c*). From the summit of (*a*) descends inwardly a broad rounded buttress, from the base of which arises, in very young lions, a small conical cusp, with distinct furrows passing from the summit to the base. This is the homologue of the tubercle (*f*). This portion is broken in our specimen of *Felis spelæa*, and the crest connecting (*a*) and (*b*) is continuous, instead of being interrupted by a cleft. This appears to be the result of wear. In other respects the teeth of the two animals resemble each other. The body of the tooth is supported by a broad flat fang, passing backwards into a shallow alveolus. This fang appears from its formation to be essentially double, and to represent the fangs

of Premolar 4. The tubercular portion is supported by a normal cylindrical fang in its proper position. It is thus seen that in this tooth all the essential parts of the permanent upper carnassial are represented, but they are so modified in form as to cause the tooth to fulfil the functions of a tubercular molar.

§ 3 β. *Milk dentition of the lower jaw.* (Pl. XIII, figs. 3, 4, 7.)—The third milk incisor, which we have represented in fig. 3, is the only one which has come before our notice; it is from Bleadon cave, and is introduced in this figure for the reason assigned above, in our account of the milk molar 2 of the upper jaw. The tooth differs from the permanent incisor, by possessing not only the posterior cusp (*c*), but also the anterior (*b*), on each side of the low, blunt, slightly recurved cone (*a*). The three cusps are traversed by a slight blunt edge, and the crown is larger than the fang, which is, as far as can be seen, subcylindrical, slightly compressed, and recurved. Of the remaining milk incisors, we know nothing but the fangs; they appear to be more equal in size to incisor 3 than in the adult animal.

The deciduous canine $\overline{DC}$ of the spelæan lower jaw (figs. 3, 4, and 7), is of so remarkable a form, that it can hardly be confounded with that of any other animal. The crown (*a*) is compressed parallel to the median line, short and recurved, without grooves on the external aspect; the flattened internal area is well defined posteriorly by the trenchant edge, anteriorly it is separated from the external surface by another ridge, passing from the tip of the crown downwards to the point where a small buttress or cusp of enamel (*b*) occupies the inner base, and gives the crown almost the appearance of a flattened upper permanent incisor three. The fang is very broad antero-posteriorly, and deeply indented on the inner surface to make way for the germ of the permanent canine. $\overline{DM\,3}$ (figs. 3, 4) is separated from the canine by a diastema, increasing with age. It consists of a stout, primary cone (*a*) inclined slightly backwards, with the secondary subequal cusps (*b*) and (*c*). The cingulum is well developed, and forms a well-marked but blunt cusp on the intero-anterior border of (*b*), and a very distinct and sharp-edged accessory cusp (*e*) posterior to (*c*). The whole tooth is traversed from the summit of (*b*) to (*e*) by a sharp trenchant ridge, the cusps being divided from each other by clefts. The cone (*a*) is smaller than its homologue in *Hyæna spelæa.* There is occasionally a supplementary, minute cusp on the internal side of (*c*). The tooth is supported by two strong, cylindrical, divaricate fangs.

The sectorial $\overline{DM\,4}$ consists of two blades, the posterior (*a*) and the anterior (*b*), and a small secondary (*c*), posterior to which the cingulum folds into the posterior accessory (*e*), which, however, is frequently obsolete. The cone (*a*) is higher than (*b*), and is inclined backwards, but less so than in $\overline{M\,1}$, which in other respects the tooth very closely resembles, both in form and in the scissor-like function that it performs with $\underline{DM\,3}$, by which it is overlapped. A trenchant edge passes from the summit of (*b*) backwards to the posterior base of the tooth, the divisions of all the cusps being strongly marked by

clefts, except between (*c*) and (*e*). The tooth is supported by two fangs, which in form and function resemble those of $\overline{\text{M 1}}$.

§ 4. *Measurements.*—The following tables of measurement in inches show the amount of variation in size of the teeth of *Felis spelæa*. Some are very much larger than any of those of the lion of modern times, while others are as small as those of the smallest recent lioness. Leonine, spelæan, and tigrine teeth form a graduated series, in which there are no valid points of specific difference.

TABLES OF MEASUREMENT.

Adult Dentition. Upper.	*Felis spelæa.*				*Felis leo.*		*Felis tigris.*	
	Bleadon. Taunton Museum.	Kent's Hole. British Museum.	Col. Wood. Ravenscliff. Figured Specimen.	Sundwig Skull. British Museum.	Large. Oxford Museum. I.	Small. Cape. Oxford Museum.	Small. Himalayah. Oxford Museum.	Nepaul. British Museum, 114 C.
Incisor 1.								
1. Length	...	...	1·29	...	...	...	...	...
2. Height of crown	...	...	0·40	0·30	0·40	0·35	0·30	0·29
3. Width of ditto	...	...	0·23	0·24	0·22	0·22	0·23	0·23
4. Circumference	...	...	...	...	...	...	...	...
Incisor 2.			Ravenscliff. Figured Specimen.	Sundwig Skull.				
1. Length	...	...	1·32	...	...	...	...	...
2. Height of crown	...	...	0·43	0·45	0·43	0·36	0·39	0·31
3. Width of ditto	...	...	0·29	0·25	0·24	0·30	0·25	0·25
4. Circumference	...	...	...	...	...	...	...	...
Incisor 3.			Figured Specimen. Sandford Hill Cave. Taunton.	Sundwig Skull.				
1. Length	1·59	...	...	...	...	...	...	...
2. Height of crown	0·59	...	0·64	0·70	0·70	0·67	0·65	0·68
3. Width of ditto	0·51	...	0·52	0·45	0·40	0·43	0·48	0·54
4. Circumference	1·43	1·55	1·40	1·45	1·50	1·30	0·90	1·51

Adult Dentiton. Upper.	*Felis spelæa.*								*Felis leo.*			*Felis tigris.*		
	Colonel Wood. Ravenscliff, Gower.	Wookey Hyæna-den. Dr. Boyd. Taunton.	Williams. Bleadon. Taunton 8.	Beard. Sandford Hill. Taunton 1.	Small figured Skull.	Colonel Wood. Gower.	Sundwig Skull. British Museum.	Crayford. Prof. Morris.	W. A. S.	Large. Oxford Museum, No. 1.	Small. Cape. Oxford Museum.	Oude. Captain Speke.	W. A. S.	Large. Nepaul. British Museum, 114 C.
Canine.														
1. Length (extreme)............	5·50	5·25	4·80	4·25	...	3·35	...	6·0	...	...	...	4·80	...	...
2. Length along the outer curve	5·75	6·00	5·52	5·00	...	3·80	...	6·8	...	...	...	5·60	...	...
3. Length of the crown	2·29	2·42	2·10	1·80	1·35	1·30	1·60	2·9	1·80	2·10	1·90	2·35	2·15	2·10
4. Circumference	...	3·76	2·77	2·70	2·30	2·20	2·50	4·1	2·15	3·10	2·60	3·00	2·90	3·00

	Felis spelæa.			*Felis leo.*			*Felis tigris.*			
	Bleadon.	In Skull figured Pl. VI and VIII.		Large. Oxford Museum.	Cape. Small. Oxford.	W. A. S.	Oude. Captain Speke.	W. A. S.	India. Capt. Thornhill. Oxford Museum.	Nepaul. British Museum, 114 C.
Premolar 2.										
1. Length	0·36	0·31	0·31	0·37	0·35	0·37	0·31	0·32	0·46[1]	0·38
2. Breadth......................	0·28	0·27	0·27	0·31	0·26	0·29	0·23	0·25	0·25	0·25
3. Circumference	1·04	0·92	0·92	1·05	0·90	0·95	0·85	0·96	1·10	1·00

[1] This specimen of tiger's $\underline{\text{PM}2}$ is two-fanged, like that of *Felis spelæa* figured Pl. XI.

	Felis spelæa.										*Felis leo.*			*Felis tigris.*		
	Beard Collection, Taunton Museum.							Skull. Hutton. Williams' Collection, Taunton.		Kent's Hole. British Museum.	Large. Oxford Museum, 602 A.	Small. Cape. Oxford.	W. A. S.	Large. Oxford. Captain Thornhill.	Small. Himalayah. Oxford.	Large. Oude. Captain Speke.
	Bleadon Cave.					Sandford Hill.										
	8	4	3	5	7	1	2	1	2							
Premolar 3.																
1. Antero-posterior measurement ...	1·27	1·25	1·21	1·03	1·02	1·13	1·15	0·89	0·95	1·08	1·05	0·90	0·90	0·93	0·90	0·95
2. Postero-transverse measurement ...	0·58	...	0·62	0·50	0·51	0·58	0·57	0·44	0·45	0·54	0·50	0·45	0·45	0·48	0·40	0·45
3. Antero-transverse measurement ...	0·40	0·51	0·51	0·40	0·41	0·41	0·50	0·39	0·39	0·48	0·40	0·45	0·38	0·39	0·30	0·40
4. Height	0·70	0·65	0·80	0·55	0·62	0·65	0·64	0·55	0·60	...	...	...	0·50	...	...	0·47
5. Circumference ...	2·99	...	3·00	2·60	2·48	2·82	2·88	2·46	2·50	2·65	2·70	2·25	2·38	2·28	2·20	2·40

Adult Dentition. Upper.	*Felis spelæa.*											*Felis leo.*			*Felis tigris.*		
	Bleadon. Williams' Collection, Taunton.		Beard Collection, Taunton Museum.							Sundwig. British Museum.	Kent's Hole. British Museum.	Large. Oxford Museum, 602 A.	Small. Cape. Oxford.	W. A. S.	Large. Nepaul. British Museum.	Small. Himalayah. Oxford.	Oude. Captain Speke.
			Sandford Hill.				Blea-don.	Hutton.									
			1	2	3	4		1	2								
Premolar 4.																	
1. Antero-posterior measurement ...	1·75	1·70	1·65	1·62	1·60	1·60	1·50	1·35	1·34	1·50	1·54	1·50	1·31	1·35	1 45	1·40	1·35
2. Postero-transverse measurement ...	0·50	0·50	0·53	0·54	0·50	0·54	0·48	0·36	0·40	0·40	0·53	0·55	0·40	0·45	0·50	0·45	0·45
3. Antero-transverse measurement ...	0·86	0·82	0·84	0·83	0·90	0·90	0·68	0·70	0·70	0·60	0·70	0·85	0·60	0·71	0·75	0·65	0·72
4. Height of crown posterior to principal lobe, in cleft	0·40	0·40	0·50	0·40	0·41	0·40	0·36	0·31	0·30	...	...	...	...	0·29	...	...	0·30
5. Circumference ...	4·20	4·00	3·80	3·80	4·04	4·00	3·78	3·39	3·31	3·50	3·60	3·60	3·20	3·14	3·85	3·10	3·60

	Felis spelæa.	*Felis leo.*			*Felis tigris.*	
	Sandford Hill. Beard. Taunton.	Large. Oxford Museum.	Small. Cape. Oxford.	W. A. S.	Large. Nepaul. British Museum.	Oude. Capt. Speke.
Molar 1.						
1. Length	52	0·40	0·36	0·50	0·48	0·45

Adult Dentition. Upper.	*Felis spelæa.*				*Felis leo.*			*Felis tigris.*		
	Large figured Maxillaries.	Small figured Skull.	Sundwig Skull. British Museum.	Col. Wood's Fragment, Ravenscliff.	Large. Oxford Museum, 602 A.	Small. Cape. Oxford.	W. A. S.	Large. Nepaul. British Museum, 114 C.	Large. Oxford Museum.	Small. Himalayah. Oxford. Without PM2.
Molar series.										
Length of	3·40	2·74	2·70	3·10	3·00	2·80	2·80	2·75	2·50	2·20

Adult Dentition. Lower.	*Felis spelæa.*			*Felis leo.*			*Felis tigris.*		
	Figured Specimen. Mendip.	Bleadon. Taunton Museum.	Sandford Hill. Taunton.	W. A. S.	Large. Oxford Museum.	Cape. Small. Oxford Museum.	W. A. S.	Oude. Capt. Speke.	Small. Himalayah. Oxford Museum.
Incisor 1.									
1. Length	1·04	Crown worn.	...	...	...	...	...	...	...
2. Height of crown	0·29		...	...	0·26	0·25	0·26	0·28	0·28
3. Width of ditto	0·20	0·20	...	...	0·15	0·17	0·15	0·20	0·28
4. Circumference	0·60	0·60	...	...	...	...	0·45	0·50	...
Incisor 2.	Sandford Hill. Figured Specimen.								
1. Length	1·35	1·38	1·25	0·93	...	...	1·0	...	...
2. Height of crown	0·35	0·38	0·32	0·25	0·32	0·30	0·30	0·34	0·34
3. Width of ditto	0 26	0·29	0·22	0·18	0·22	0·20	0·24	0·20	0·24
4. Circumference	0·80	0·85	0·75	0·65	...	...	0·70	0·75	...
Incisor 3.									
1. Length	1·65	1·51	...	1·20	...	...	1·30	...	...
2. Height of crown	0·45	0·47	...	0·40	0·68	0·40	0·40	0·40	0·44
3. Width of ditto	0·42	0·33	...	0·29	0·28	0·27	0·30	0·30	0·35
4. Circumference	1 05	1·00	...	0·98	...	...	0·87	0 90	...

	Felis spelæa.								*Felis leo.*			*Felis tigris.*		
	Williams' Collection at Taunton, from Bleadon.					Beard Col., from Sandford Hill.	Col. Wood. Ravenscliff, Gower.	Oreston. Jermyn Street.	W. A. S.	Large. Oxford Museum.	Cape. Small. Oxford Museum.	Oude. Capt. Speke.	W. A. S.	Small. Oxford. Himalayah.
	1	11	12	9	5									
Canines.														
1. Length of outer curve	5·40	5·00	5·50	5·50	4·20	4·78	...	3·9	...	...	...	...	...	...
2. Length of crown	2·10	1·60	1·70	2·10	1·50	1·90	1·30	1·5	1·50	1·60	1·58	1·95	1·70	1·65
3. Antero-posterior diameter	1·10	1·20	1·20	1·10	0·98	1·10	0·90	0·85	0·90	1·15	0·87	1·07	1·00	0·82
4. Circumference	3·25	3·20	3·20	3·10	2·60	2·80	2·10	...	2·10	2·90	2·50	2·75	2·45	2·10

Adult Dentition. Lower.	*Felis spelæa.* Williams' Collection at Taunton, from Bleadon. 1	2	Beard Collection. Figured Specimen in Pl. I.	14, Bleadon.	Figured specimen in Pl. IV.	W. B. Dawkins. Wookey Hyæna-den. 1	2	*Felis leo.* W. A. S.	Large. Oxford Museum.	Cape. Small. Oxford Museum.	*Felis tigris.* W. A. S.	Oude. Capt. Speke.	Small. Oxford. Himalayah.
Premolar 3.													
1. Antero-posterior measurement	0·80	0·80	0·78	0·84	0·62	0·66	0·60	0 57	0·80	0·70	0·58	0·58	0·78
2. Maximum transverse ditto	0·50	0·45	0·42	0·47	0·34	0·35	0·34	0·29	0·40	0·40	0·34	0·34	0·32
3. Height of crown	0·54	0·53	0·46	0·47	0·39	0·38	...	0·30	...	...	0·34	0·34	...
4. Circumference	2·10	2·10	2·10	2·20	1·60	1·72	1·62	1·52	2·10	1·80	1·52	1·70	1·72
5. Transverse measurement, anterior lobe	0·36	0·34	...	0·37	...	...	...	...	0·30	0·28	...	...	0·28

	Felis spelæa. Williams' Collection, from Bleadon Cave. 1	2	3	5	*a*	*b*	Beard Collection. Figure of Jaw, Pl. I. 1	2	Figure of Jaw, Pl. VI.	*Felis leo.* W. A. S.	Large. Oxford Museum.	Cape. Small. Oxford Museum.	*Felis tigris.* W. A. S.	Oude. Capt. Speke.	Small. Oxford. Himalayah.
Premolar 4.															
1. Antero-posterior measurement............	1·25	1·16	1·10	1·20	1·30	1·29	1·22	1·25	0·90	0·95	1·20	1·00	0·90	1·00	0·90
2. Width of crown, maximum	0·64	0·52	0·50	0·55	0·60	0·54	0·54	0·57	0·41	0·50	0·60	0·50	0·46	0·49	0·48
3. Height of crown	0·88	0·75	0·60	0·80	0·80	0·84	0·78	0·80	0·58	0·60	...	...	0·53	0·60	...
4. Circumference	3·10	2·90	2·70	3·00	3·19	3·10	3·08	3·03	2·28	2·35	2·85	2·35	2·20	2·60	2·30
5. Transverse measurement of anterior lobe..................	0·50	0·49	0·43	0·49	...	...	...	...	...	0·38	0·45	0·40	0·30	0·40	0·40

	Felis spelæa. Wookey Hyæna-den. Sanford.	Williams' Collection, from Bleadon. 1	3	4	5	Beard Coll., Bleadon. 4	5	*Felis leo.* W. A. S.	Large. Oxford Museum.	Cape. Small. Oxford Museum.	*Felis tigris.* W. A. S.	Oude. Captain Speke.	Small. Oxford. Himalayah.
Molar 1.													
1. Antero-posterior measurement	1·03	1·30	1·10	1·30	1·15	1·28	1·20	1·02	1·05	1·05	1·00	1·10	1·00
2. Width of crown, maximum ...	0·56	0·60	0·40	0·60	...	0·60	0·58	0·51	0·50	0·48	0·50	0·56	0·40
3. Height of crown at cleft	0·30	0·50	0·50	0·45	...	0·43	0·42	0·32	...	...	0·33	0·36	...
4. Circumference	2·60	3·05	2·70	3·25	2·90	3·05	3·00	2·50	2 60	2·50	2·40	2·70	2·40

The length of the molar series is given in the measurements of the lower jaw, page 5.

MILK DENTITION. Upper.	Felis spelæa.						Felis leo.		
	Bleadon. Figured Specimen.	Williams and Beard, from Hutton and Sandford Hill.					W. A. S.	British Museum, 112 F.	Felis tigris. Brit. Mus., 114 G.
		1	2	3	4	5			
Canine.									
1. Antero-posterior measurement	0·49	0·40	0·46	0·45	0·40	0·42	0·36	0·29	0·39
2. Transverse measurement	0·30	0·30	0·32	0·30	0·30	0·32	0·24	0·20	0·28
3. Height of crown	0·91	0·75	0·89	0·81	0·70	0·85	0·66	0·50	0·72
4. Circumference	1·25	1·20	1·18	1·21	1·10	1·15	1·00	0·80	1·10

	Felis spelæa. Bleadon. Figured Specimen.	Felis leo. British Museum, 112 F.	Felis tigris. British Museum, 114 B.
Milk Molar 2.			
1. Length	0·14	0·15	Not in the skull.
2. Width	0·11	0·12	
3. Height	0·09	0·10	
4. Circumference	0·30	0·40	

	Felis spelæa.				Felis leo.		
	Hutton. Figured Specimen.	Hutton.	Sandford Hill.		W. A. S.	British Museum, 112 F.	Felis tigris. Brit. Mus., 114 G.
			1	2			
Milk Molar 3.							
1. Length	1·00	1·06	0·93	0·93	0·91	0·87	0·92
2. Width of anterior lobe	0·27	0·35	0·30	0·26	0·25	0·22	0·21
3. Ditto of posterior lobe	0·33	imp.	0·30	0·28	0·30	0·24	0·21
4. Height of crown	0·50	0·54	0·50	0·50	0·46	0·42	0·40
5. Circumference	2·35	2·40	2·30	2·28	2·05	2·00	2·00

Milk Dentition. Upper.	*Felis spelæa.* Hutton. Figured Specimen.	*Felis leo.* W. A. S.	*Felis leo.* Brit. Mus., 112 F.	*Felis tigris.* British Museum.
Milk Molar 4.				
1. Length	0·28	0·25	0·25	0·25
2. Width	0·50	0·50	0·43	0·40
3. Height	0·23	0·18	0·18	0·15
4. Circumference	1·37	1·10	1·10	1·00

	Felis spelæa.	*Felis leo.*	*Felis tigris.*
Length of milk molar series	1·56	1·52	1·52

Milk Dentition. Lower.	*Felis spelæa.* Bleadon. Taunton Museum. Figured Specimen.	*Felis leo.* Young unworn Tooth. W. A. S.	*Felis tigris.* British Museum, 114 G.
Incisor 3.			
1. Length of crown	0·22	0·16	0·16
2. Width of ditto	0·20	0·12	0·12
3. Circumference	0·50	0·36	0·40

	Felis spelæa. Sandford Hill. Taunton. Figured Jaw. 1	*Felis spelæa.* Sandford Hill. Taunton. Figured Jaw. 2	*Felis spelæa.* Bleadon.	*Felis spelæa.* Mendip. Taunton Museum. 1	*Felis spelæa.* Mendip. Taunton Museum. 2	*Felis spelæa.* Mendip. Taunton Museum. 3	*Felis leo.* Brit. Mus., 112 F.	*Felis tigris.* Brit. Mus., 114 G.
Canine.								
1. Antero-posterior measurement	0·50	0·48	0·55	0·50	0·48	0·44	0·33	0·42
2. Transverse measurement	0·21	0·22	0·25	0·25	0·26	0·21	0·16	0·20
3. Height	0·72	0·78	imp.	0·76	0·75	0·72	0·50	0·60
4. Circumference	1·20	1·28	1·20	1·40	1·30	1·10	0·80	1·0

Milk Dentition. Lower.	Felis spelæa.					Felis leo. Brit. Mus., 112 F.	Felis tigris. Brit. Mus., 114 G.
	Sandford Hill. Taunton.	Bleadon Cave. Taunton. 1	2	3	Hutton Cave. Taunton.		
Milk Molar 3.							
1. Antero-posterior measurement ...	0·53	0·60	0·70	0·60	0·51	0·50	0·50
2. Transverse, anterior lobe	0·23	0·25	0·27	0·25	0·22	0·20	0·18
3. Transverse, posterior lobe	0·26	0·28	0·27	0·30	0·26	0·21	0·22
4. Height of crown....................	0·40	0·40	0·45	0·44	0·34	0·33	0·30
5. Circumference	1·30	1·40	1·60	1·50	1·30	1·20	1·20

	Felis spelæa.				Felis leo. Brit. Mus., 112 F.	Felis tigris. Brit. Mus., 114 G.
	Sandford Hill. Taunton Mus.	Bleadon Cave. Taunton. 1	2	Hutton Cave. Taunton.		
Milk Molar 4.						
1. Antero-posterior measurement	0·68	0·80	0·85	0·67	0·67	0·70
2. Transverse measurement of anterior lobe	0·26	0·30	0·25	0·25	0·23	0·22
3. Ditto ditto, posterior lobe	0·27	0·50	0·35	0·30	0·24	0·21
4. Height of anterior lobe	0·41	0·45	...	0·38	0·39	0·35
5. Ditto of posterior lobe	0·46	0·50	0·55	0·44	0·43	0·40
6. Circumference	1·65	1·80	2·00	1·70	1·50	1·60

	Felis spelæa.			Felis leo. Brit. Museum.	Felis tigris. Brit. Museum.
	Sandford Hill.	Bleadon.	Hutton.		
Molar series.					
Length of.....................	1·20	1·30	1·20	1·25	1·20

CHAPTER VIII.

Vertebræ, Sternum, Pls. XIV, XV, XVI.

CONTENTS.

§ 1. *Introduction.*
§ 2. *Atlas.*
§ 3. *Axis.*
§ 4. *Third, Fourth, Fifth, Sixth, Seventh Cervical Vertebræ.*
§ 5. *Dorsal Vertebræ.*
§ 6. *Lumbar Vertebræ.*
§ 7. *Sacral* ,,
§ 8. *Caudal* ,,
§ 9. *Comparative Measurements.*
§ 10. *Literature.*
§ 11. *Sternum.*

§ 1. *Introduction.*—The vertebral column in the genus Felis is tolerably constant as to the number of the vertebræ, except as regards the tail. For the most part the numbers are—cervical 7, dorsal 13 (rarely 12), lumbar 7, sacral 3; in the tail the number varies considerably, not only in different species, but also in different individuals of the same species. In the larger old-world forms it generally exceeds 20; Cuvier[1] assigns 26 to the lion, 25 to the tiger, 24 to the panther: these probably exceed the average. The jaguar has fewer, generally under 20.

We are fortunately enabled to give figures of the more important vertebræ from the Somerset specimens at Taunton, and have been aided in our examination, and in one instance in completing the figure, by the series of casts from Gailenreuth, which have been presented by Sir Philip G. Egerton, F.R.S. to the Museum of the College of Surgeons and the British Museum. We have found a very close agreement between

[1] 'Leçons d'Anatomie comparée,' ed. 1835, vol. i, p. 180.

the German and the English specimens, and therefore have not scrupled to use them both in restoring outlines.

§ 2. *Atlas* (Pl. XIV, figs. 1, 1′, 1″).—The only British specimen that we have seen is the central portion, without the transverse processes, of a very fine and large atlas from Sandford Hill Cave, in the Taunton Museum. It is that of a full-grown, though still young animal, and closely agrees in condition and age with the larger skull in the same collection. It is somewhat larger than a cast from Gailenreuth; but as it agrees with it in other respects, we have restored the transverse process (*pl*) by copying that of the German specimen, somewhat larger than nature.

The centrum of this vertebra being the odontoid process of the axis,[1] that which is often described as the centrum is the "hypapophysis" (*hy*). It is of moderate thickness, without epiphyses, somewhat thicker centrally than proximally or distally, but showing hardly any trace of the anterior tubercle on the ventral surface, which slight trace, however, afforded origin to the first of the series of five muscles which answer to the "longus colli" in man. The hypapophysis ends proximally in a well-defined notch between the glenoid or proximal zygapophyses (*az*), and distally in a well-defined tubercle between the axial or distal articulations. This tubercle gives attachment to a strong ligament, the "axo-atloid," which unites the atlas with the axis. The odontoid articulation on the inner surface of the ventral portion of the ring is well defined and slightly raised, having a slightly depressed and roughened space between it and the tubercles for the "transverse ligament" on the inside of each neurapophysis (figs. 1, 1″, *e*).

The neurapophyses are, as in the recent lion, ample, and of considerable proximo-distal length, and at their symphysis affect the form of a low neural spine that is slightly bifurcated proximally, and affords an attachment for the origin of the "rectus minor posterior capitis."

The very great projection of the proximal zygapophyses (*az*) beyond the transverse processes affords a means of distinguishing the atlas belonging to *Felis spelæa* from that of *Ursus spelæus*, or *U. arctos*. In *Ursus maritimus*, however, or the Polar bear, the same projection is visible. They are separated by a deep broad notch on the dorsal margin of the ring (fig. 1, *o*), to which the ligament that bridged over the space between the atlas and the skull was attached, and the dorsal edge of each is interrupted by a small but well-defined notch, which, however, is not constant in the recent lion (fig. 1, *b*). The distal or axial zygapophyses (*pz*) form flat broad articulations exactly as in the lion, diverging nearly at right angles from each other, and separated through the greater part of their extent by the entire width of the spinal canal; but they send prolongations along the ventral edge of the ring, so that they are only separated by the small tubercle mentioned above, which terminates distally the hypapophyses (fig. 1″, *r*).

[1] Owen, 'Homol. of Vert Skeleton,' p. 93.

The very wide and massive transverse process is composed, as usual, of the di-, par-, and pleur-apophyses, the distal and ventral portion being the latter (figs. 1′, 1″), and the proximal and dorsal the former. Between these and their attachment to the neurapophyses passes the canal for the vertebral artery (*v*), which thus perforates the base of the process in a longitudinal direction, having its distal orifice (fig. 1″, *v*) on the superior or dorsal surface, close to the external edge of the axial articulation, and its proximal in the infero-lateral surface (fig. 1, *v*). The vestibule leading to this orifice is shared also by the smaller foramen that perforates the diapophysis horizontally. The canal does not at this point as in the hyæna perforate the diapophysis vertically, but it passes round the proximal edge of the process in a dorsal direction, to the orifice of the larger foramen which perforates the upper part of the neurapophyses close to the zygapophyses, and gives a passage at once to the vertebral canal and the sub-occipital nerve (fig. 1′, *s*).

The arrangement of these canals is precisely the same in Felis, Lutra, and Canis; but the anterior canal, which is in those animals the simple deep groove above described, is arched over by an inward prolongation of the anterior edge of the diapophyses in Ursus and some other carnivora. M. de Blainville states[1] that a difference exists in this bone between the lion and tiger, which we have not been able to verify. "L'atlas offre l'orifice d'entrée du canal carotidien bien plus marginal que dans le lion." We do not know to which orifice of the vertebral artery this alludes, but we are unable to find any constant distinction in the positions of the openings of either of the foramina of this bone in either of the above animals; and allowing for such individual variations as we have met with in them, we can see no difference between the fossil and recent forms in this respect.

The roughened surface below the large ventral foramen is the principal origin of the "levator scapulæ" "transverso-scapularis" of Straus-Durckheim, and also of the proximal root of the "rectus anticus capitis major." Within this again is the lesser muscle of the same name as the last, the two acting together as flexors of the neck.

In the figures[2] given by M. de Blainville of the atlas in lion and tiger considerable differences appear to exist in the outline of the transverse processes. We presume that M. de Blainville found, as we have, that these differences were not constant, as he has not alluded to them in his text. It appears to us that the form of the bone, as seen in the English and German specimens, and that of the transverse process in the latter, is about intermediate between those of the lion and tiger as represented in M. de Blainville's plate.

We have represented the Somerset bone in three aspects, from which, perhaps, a better idea of the exact form is given than by the most elaborate description.

The great surface afforded on the dorsal aspect by this bone indicates a very great power that must have existed in the "obliquus superior" muscle, which is inserted

[1] 'Ost. Felis,' p. 28. [2] 'Ibid.,' pl. xi.

over the whole dorsal surface of the transverse process, taking its origin from the spine of the axis. The principal office of this muscle is to shake and rotate the head through the medium of the atlas; it is connected with the tearing and worrying power of the animal. The *Hyæna spelæa* may have had greater leverage, for the transverse process is somewhat longer proportionally; but the great European lion had far greater surface, owing to the far greater proximo-distal measurement, and the muscle was probably of enormous power. The external angle of the transverse process affords the insertion to the first isosceles and the first scalene; the first originating on the diapophysis of the axis and the neurapophyses of the four next cervicals; and the latter on the diapophyses of the five posterior cervicals. These serve as lateral flexors of the head.

§ 3. *Axis.*—The only part of the axis which has occurred to us from any British locality is the odontoid process, with the anterior zygapophysis. These closely resemble the same part in lion and tiger, except in size. The odontoid process is longer and more pointed in the genus Felis than in the bear; but there is no difference that we can describe observable between the zygapophysis in any of the larger carnivora. The proximo-distal length of the neurapophysis offers a means of distinction, it being considerably longer in the Felidæ than in the Ursidæ.

Fragment from Sandford Hill, at Taunton.

	INCHES.
Length of the odontoid process	1·23
Width at base of do. do.	0·90
Height do. do. do.	0·90
Width of anterior zygapophysis	3·50

§ 4. *Third, Fourth, Fifth, Sixth, Seventh Cervicals.*—The remaining cervical vertebræ of the whole of the terrestrial carnivora are remarkably alike. The elliptical section of the centrum (*c*), with articular epiphyses more or less inclined to the spinal axis, the ample neural arch (*n*) and large lateral arterial canals, the broad flat zyapophyses (*az*, *pz*), and well-developed and widely spread diapophyses (*d*), from which descend, increasing in depth and complexity of outline from the third to the sixth, the pleurapophysial plates (*pl.*), the absence of a vertebral canal in the seventh vertebra, are characters common to the whole of the order; and it is only by a close comparison between the forms which are near to each other in size that they can be effectually differentiated.

The only cave vertebræ that are likely to be confounded with the cervicals of *Felis spelæa* are those of bear, about the size of large *Ursus arctos*.

From the ursine cervicals, the following points will be found sufficient to distinguish those of the large Felines. They are generally longer in proportion to width, particularly the third and fourth; and this is very evident in the broad upper surface of the neurapophyses (*n*); the diapophyses of the third, fourth, and fifth vertebræ are less detached and less angular in section in Felis than in bear, and form a sharper curve upwards, and thus are brought nearer to the zygapophyses. The articular epiphyses of the centrum are more sharply inclined to the spinal axis in Felis, and the inferior border of the pleurapophysis passes from the anterior orifice of the arterial canal backwards, in a more or less gentle sweep in the bear, whereas in Felis it is brought more or less forwards, forming a more or less decided anterior process before passing backwards in a waved sweep to the posterior angle.

Most of the specimens of these vertebræ of *Felis spelæa* that have passed through our hands are from Bleadon Cave, and are badly crushed and mutilated. We have, however, been able to make out the following—two fourth, one fifth, and one sixth. We have, also, one sixth cervical, which was sufficiently perfect to figure, from Sandford Hill (Pl. XIV, figs. 2, 2′, 2″, 2‴). No specimen of the third or seventh has occurred to us.

The best specimen of the fourth closely resembles that of a lion, except in size. The centrum is tolerably perfect, with the lateral canals and the greater part of the neurapophyses, both post- and the right pre-zygapophyses; but the neural spine and the di- and pleur-apophyses are gone. All its proportions are larger than those in lion. It shows slight evidence of exostosis under the epiphyses, a disease to which, as well as the recent, the fossil carnivora appear to have been subject. The second specimen, which is much less perfect, is about the size of that of ordinary lion. The single fifth from Bleadon, though a good deal crushed, is perfectly recognisable throughout. The centrum with both arterial canals, the right diapophysis with part of its pleurapophysis, and the right neurapophysis with its zygapophysis, are nearly perfect. The rest is broken away. This specimen belonged to an animal quite as large as that indicated by the largest other bones we have met with; it does not, however, differ in any other recognisable respect from the recent species.

Of the sixth vertebra, one specimen from Bleadon, much mutilated, agrees exactly with that of a rather large recent lion or tiger. The other, from Sandford Hill, appears, from the texture of the bone, to have belonged to a young but fully adult animal, rather smaller than that to which the atlas we have figured belonged, but still larger than the average lion. Its feline characters are—the somewhat greater antero-posterior length of the neurapophyses (*n*), when compared with those of the bear; the anterior edge, which connects the pre-zygapophyses (*az*), and the diapophyses (*d*), being well rounded instead of being flattened and angular, as in the bear; the diapophyses, also, stand more clearly out from the pleurapophyses (*pl.*), and the ridge forming the inferior edge of this process is directed forwards towards the anterior angle of the pleurapophysis, instead of downwards and backwards to the posterior angle, as in the bear. The anterior border of the pleura-

pophyses, though broken, projects too much forward to be restored as the same part in any of the larger bears. The posterior angle of the same process closely resembles the same part in tiger, of which animal we have seen specimens with the neural spine (*ns*), of precisely the same form as our fossil. The sweep of the curve formed by the di- and neur-apophyses is more open than usual in *Felis*, and in this the fossil resembles bear, as also in the greater inclination of the zygapophysial articulations; but we have met with feline (and especially tigrine) vertebræ which have quite as great an inclination.

We have already indicated the principal muscles which connect the head with the neck in Felis, as also those which belong to the atlas.

The posterior portion of the "longus colli" in man is represented in Felis by a powerful muscle, which has its origin on the centra of the six anterior dorsal vertebræ, and its insertion on the strong ligament called the "cord of the sixth cervical," which connects the anterior with the posterior process of the pleurapophysis of that vertebra. Other heads unite the centrum of the first dorsal with the pleurapophyses of the third, fourth, and fifth cervicals. The anterior part of the "longus colli" is represented by a series of small muscles, which pass diagonally inwards from the anterior edges of the cervical pleurapophyses to the centra of the vertebræ anterior to those from which they take their origin. The "rectus anterior capitis" may be considered to represent the first of this series. These muscles are the principal direct flexors of the head, and their power may, to a certain extent, be estimated from that of the pleurapophyses to which they are attached. They are aided indirectly by others, acting also as lateral flexors, which are analogous to the scalene muscles in man, and are divided by Straus-Durckheim into two series; the "isosceles," equivalent to the "anterior scalene," and the "scalene," equivalent to the "middle and posterior scalene" in man. The former unite the diapophyses of each vertebra with the pleurapophyses of those posterior to them, and the latter uniting in the first place the diapophyses together, thus representing the "cervicalis descendens" in man; and secondly, these processes, with the ribs, answering, as far as the neck is concerned, to the "scalenus anticus," "posticus," and "medius," in man, but succeeded in the back of Felis by others, which are simply a continuation of the series passing from the ribs, as far back as the eighth pair, to the diapophyses of the cervical vertebræ.

The "inter-transversales colli" are stout muscles which pass from one diapophysis to that immediately succeeding it, and similarly the "intercostals" pass from one pleurapophysis to another. All these aid as lateral flexors.

There are other muscles which have both their origin and insertion in the diapophyses of the vertebræ. They form one series in the cat; the anterior portion of them, which pass from the diapophyses of the different vertebræ to those preceding them, and also to the anterior dorsals, equivalent to the "transversalis colli" of man; and the second portion more particularly belonging to the back, are equivalent to the "latissimus dorsi" in human anatomy. The "interspinales" are between the neural spines, and are necessarily very

slight, the attachments being only the knife-like edges of these parts of the vertebræ. The "spinalis dorsi," taking its origin on the neural spines of the last two dorsals and the first three lumbars, is inserted in the same part of the last two cervicals and the first eight dorsals. This muscle belongs to the same order as the "splenius," which we have described in our account of the head, and with it and the "transversalis colli" and "interspinalis" constitutes the principal "extensors," or lifters of the neck.

The rotation of the neck is performed by the "multifidi spinæ," which, originating in the prezygapophyses of the five last cervicals, are inserted in the neural spines of the vertebræ preceding those from which they arise; their arrangement is somewhat complicated.

The "serrati" muscles do not appear to be connected directly with the neural spines, but with aponeurosis common to these and to other muscles. The "serratus major" is thus connected with the last five cervicals, and its heads are inserted on the spine of the scapula, which it retracts. In the same way the "acromio-circularis" of Straus-Durckheim, answering to the posterior portion of the trapezius in man, is connected by the cervical ligament with the spine of the axis, it being inserted on the spine of the scapula about the middle of its length. Passing backwards, this is followed by the "rhomboid," which is in the same way indirectly connected with the spines of the other cervicals; the two with the "transverso-scapularis," or "levator anguli scapulæ," described in our account of the "atlas," act together as elevators of the scapula.

§ 5. *Dorsal Vertebræ* (Pls. XV, XVI, figs. 1, 2.)—The dorsal vertebræ of the carnivora may be divided into four distinct forms—the first or cervical form, the second or dorsal proper, that to which the dorsal and lumbar neural spines converge, and those which resemble the lumbar vertebræ, and are often called rib-bearing lumbars. In some carnivora, such as the hyæna, these last three classes merge one into the other; in Felis the differences are very marked.

In Felis the first dorsal closely resembles the last cervical; but it is distinguished at sight from it by the much shorter diapophyses terminated by the pleurapophysial articulation, as also by the articulation for the necks of the first and second ribs on the centrum, and by the longer neural spine. The centrum is also wider, as it affords space in the width for the rib articulations above mentioned. From the corresponding vertebra of the bear it is easily separated by the much greater inclination of the epiphysial articulation to the axis of the spine, and by the greater comparative length of the centrum; the prezygapophysial interval is also much narrower, and the mass formed by the union of the prezygapophysis and the diapophysis is much smaller. The slight metapophyses of the ursine vertebra are also absent. The neural spine is also less upright, and the pleurapophysial articulation on the post-epiphyses are larger, flatter, and more on the same level with the rest of the articulation than in the case of the bear.

Two specimens of this vertebra have occurred to us, which we refer to *Felis spelæa*;

the one is a good deal larger than that of ordinary lion, and consists of the centrum, the neurapophysis with the root of the neural spine, the right prezygapophysis with postzygapophysis and the roots of the diapophyses: the other is more mutilated, and does not differ in size from the corresponding vertebra in lion.

The second dorsal in Felis is intermediate in form between the first and the remainder of the typical dorsal series. The centrum (*c*) is elliptical in section, and the prezygapophyses (*az*) are widely separated, as in the cervicals, but the postzygapophyses (*pz*) are nearer together under the neural spine, as in the other dorsals. We have one specimen of this vertebra from Sandford Hill in the Taunton Museum. It is all but perfect, and we have devoted an entire plate (Pl. XV) to its illustration.

We can detect no difference whatever between it and that of the lion or tiger, except size and the length of the neural spine (*ns*); but the amount of inclination of the latter is exactly the same as in the larger Feles. In comparing several skeletons of these species, we have not the neural spine of exactly the same form in any two; in most the form is slightly sigmoid, the bend backwards near the summit being very decided.

The large mounted skeleton of the lion in the College of Surgeons has the neural spine of this vertebra precisely of the form of that of our fossil. It is, however, slightly shorter. We have also met with vertebræ of the jaguar[1] and leopard which closely resemble it in general appearance.

The greater length of this spine would indicate greater carrying power in the *Felis spelæa* than in ordinary lion and tiger. There is also another slight difference; at the posterior base of the spine (Pl. XV, fig. 1″) there is a deep and somewhat large hollow in the fossil. This occurs occasionally in all the dorsal vertebræ of carnivora, and we have found precisely the same formation in the jaguar, and it is evidently only varietal in importance.

In comparing the vertebra with the corresponding one of the bear, we find that the centrum of the latter is proportionally much wider and shorter. The diapophysial articulation (*d*) for the tubercle of the rib is much larger, the posterior parapophysial articulation (fig. 1′, *pc*) for the head of the rib is much flatter, larger, and more even with the epiphysial articulation. The diapophyses (figs. 1, 1′, 1″, *d*) are much wider, and with the prezygapophyses (*az*) form a much larger mass, furnished like the first dorsal, with metapophyses, which do not appear in Felis. The prezygapophyses are also flatter, and do not turn upwards at any part towards the neural spine, as is the case in this vertebra; and, as in all the Felis we have met with, the post-zygapophyses (*pz*) are also flatter, further apart, and afford a less firm lock with the third vertebra in bear than in Felis. The posterior edges of the diapophyses are formed by sharp ridges between the pleurapophysial articulations and the post-zygapophyses; but this ridge in our specimen, as in all recent Feles, forms a short concave curve, where as in bear the edge forms a long, straight, or rather convex ridge.

[1] See also plate of skeleton of jaguar, De Blainville, 'Ost. Felis,' pl. iii.

The next eight constitute in Felis the dorsal vertebræ proper or characteristic. The general form is the same throughout. The cylindrical centra, with flat epiphyses, are at right angles to the spinal axis, the parapophysial articulations for the heads of the ribs sit well on the side of the anterior epiphyses. The short, strong, but not over-massive diapophyses with the flat articulations for the tubercles of the ribs and the well-defined metapophyses projecting inwards and upwards from the head of the diapophyses, the flat prezygapophyses but slightly inclined to each other and to the spinal axis, lying on the top of the neurapophyses, and the equally flat post-zygapophyses lying well under the posterior base of the neural spine, and but slightly separated from each other, are characters common to the whole series of these vertebræ. The neural spine is also well developed, but decreases in height and increases in inclination from the third to the tenth, and by this means the vertebræ can be distinguished from each other, as well as by the length of the centra, and also of the neurapophyses where they join the centra, and by the projection of the prezygapophyses in front of the centra; of these, the first two increase, while the last decreases backwards. Unless we have bones from the same animal, it will be always a matter of doubt whether a given vertebra is, say, the seventh or eighth, or the eighth or ninth; for these characters vary within small limits in different individuals. The form of the neural spine also varies, but it is generally more or less sigmoid in outline, though often nearly straight.

In comparing these vertebræ with those of the Bear, the latter are much shorter, and somewhat deeper, the zygapophyses are wider apart, and the diapophyses longer, and the metapophyses in general less developed. The anterior base of the neural spine is flatter, and the inclination of the spine is generally greater, but the latter appears to be variable in the Bear.

Of this part of the vertebral column of *Felis spelæa* we have only two vertebræ, both from Bleadon. One of them is sufficiently perfect to figure (Pl. XVI, fig. 1, 1′). It consists of the centrum with the neurapophyses, and a portion of the neural spine, the zygapophyses, and the left diapophysis, of which the metapophysis is broken. It agrees closely in all respects with the seventh dorsal of the Lion, except that the inclination of the spine is about that of an average specimen of the eighth. The last character, however, being variable, we consider it a seventh dorsal. The other is a good deal rubbed and broken, and both diapophyses are gone, but in other respects it is much in the same condition as the last. As the neurapophyses are slightly longer, we consider it to be an eighth. Both specimens much exceed those of an ordinary Lion in size.

Of the third form of the dorsal vertebræ, the eleventh, we have a single specimen, nearly perfect, from Bleadon (Pl. XVI, fig. 2, 2′, 2″, 2‴). This is the vertebra to which the neural spines of the lumbar and dorsal vertebræ converge, and by some is called the last true dorsal. It is distinguished by the extreme shortness of the neural spine, by the great backward projection of the post-zygapophyses, by the length of the centrum, by the great size of the metapophyses, which project backwards so as to

13

indicate a passage to the development of the anapophyses on the suceeeding vertebra. In other respects it resembles the other true dorsals. It differs from the corresponding bone of the Bear in the much greater length and smaller depth of its centrum, and the smaller size of the neural spine. The prezygapophyses are also flat, and lie on the top of the neurapophyses in the Lion, whereas they are inclined to each other, and lie more on the metapophysis in the Bear. The neural notch is also deeper in the former than in the latter; the centrum is keeled in Bear, but is rounded in Lion. Our specimen agrees with that of Lion, excepting that the whole specimen is proportionally somewhat wider. It is of very large size.

The length of the centrum, which is so apparent in all the vertebræ of Felis when compared with Ursus, is still more decided as we approach the lumbars. The fourth class of dorsals, lumbo-dorsals, or rib-bearing lumbars, as they are sometimes called, approach the lumbars proper closely in form. They are provided with strong perpendicular metapophyses and horizontal backward projecting anapophyses so disposed that the postzygapophyses projecting far beyond the centrum, lock between the metapophyses of the succeeding vertebra, which are again locked by the anapophyses of that preceding. There is but one costal articulation, *i. e.* the parapophysial on the side of the centrum, close to the anterior epiphyses. There is no trace of a diapophysis on the first of these or the twelfth, but on the second or thirteenth a minute tubercle above the parapophysis shows the trace of the lumbar form of this process. We have one imperfect specimen of the second of this form of vertebra from Sandford Hill Cave without epiphyses, and otherwise much broken. The diapophysial tubercle can be just traced; we can find no distinguishing mark between it and that of large recent Feles.

§ 6. *Lumbar Vertebræ* (Pl. XVI, fig. 3, 3′, 3″, 3‴).—Although the lumbar vertebræ of the smaller Feles resemble those of some other carnivora of similar size, we know of none that can be compared with those of the larger forms, such as Lion, Tiger, and *Felis spelæa*. Perhaps, generally speaking, the tendency in the two latter is to somewhat greater length of centrum than in the Lion; but we have met with lumbars of the Lion in which the proportions are identical with those of the largest and longest Tiger, and differing in nothing but size from those of the largest *Felis spelæa.*

The long centra, with elliptical section and flat epiphyses, the broad, flat-sided neurapophyses from the lower edge of which descend and project forward the strong diapophyses gradually increasing in length from the first to the sixth, are characters which, taken together, at once distinguish the large feline lumbars from any of similar size.

In addition, the metapophyses supporting the flat prezygapophyses are well developed on all the lumbars. The postzygapophyses, which are very narrow on the first, gradually increase in width to the sixth, and are very wide on the seventh, which articulates with the sacrum. The anapophyses passing under and locking with the metapophyses of the succeeding vertebræ, are largely developed in the first, but decrease in size backwards,

till on the sixth they are represented by minute tubercles that disappear on the seventh. The neural spines resemble those of many other carnivora, being narrower at the summit than at the base, with flat, enlarged, nail-headed summits and sharp edges. We have been enabled to trace more or less of these characters in every lumbar vertebra of *Felis spelæa*, except the first, of which we have not met with a specimen.

Of the second we have seen two: one, that of a young but full-grown animal, is without epiphyses, and is otherwise much mutilated; the other (Pl. XVI, fig. 3, 3′, 3″, 3‴), is almost perfect, with the exception of the neural spine. It is distinguished by the size of the dia- and anapophyses, and by the absence of the keel on the ventral aspect of the centrum, which is well developed on the three next vertebræ. This vertebra, as well as the next four, also possesses a well-marked ridge, with deep lateral depressions along the floor of the neural canal, and in the centre of these are foramina for the vessels which supply the bone.

Of the third we have a specimen, without epiphyses, neural spine, and posterior zygapophyses. The inclination and size of the diapophyses, and the presence of the inferior keel, show this to be a third lumbar.

The fourth is represented by a specimen also without epiphyses, the left postzygapophyses, the neural spine, and the ends of the diapophyses. Enough, however, of the latter is left to determine by the amount of the inclination downwards and forwards, that it is a fourth lumbar; it is provided with a very distinct keel, and the left anapophysis is also clearly seen. All the above specimens are from Sandford Hill Cave.

Of the fifth lumbar we have, as far as we can judge from their mutilated condition, three specimens, all simply centra, from Bleadon; one of them is about the size of that of an ordinary Tiger, and the others are of the largest size. They are distinguishable by their great length and by the slight development of the keel, which only extends to half the length of the vertebra.

The sixth lumbar is represented by two specimens; one from Sandford Hill and the other from Bleadon. Both are in nearly the same state, excepting that the former has no epiphyses; of both the neurapophyses and zygapophyses are nearly perfect, with portions of the diapophyses, and the anapophysial tubercle is seen on both. Neither of them possesses any keel, which is also absent from the corresponding vertebræ of Tiger. It is, however, frequently present in the anterior part of that of the Lion. The postzygapophyses of the Sandford Hill specimen are narrow, but in the specimen from Bleadon Cave they are of the normal width. The inclination and size of the roots of the diapophyses exactly agree with those of the sixth lumbar in the Lion.

The seventh is represented by a large specimen from Bleadon; it exactly agrees with Lion in everything but size. It is easily distinguished from the others by being much shorter, by the slight inclination of the epiphyses, and by the width of the postzygapophyses which articulate with the sacrum, and by the width and depth of the neural notches. It has no vestige of a keel on the ventral, and but a slight one on the neural

surface of the centrum. The corresponding vertebræ of the Bear are easily distinguished by the extreme shortness of their centra. This shortness indeed characterises the whole of the chain of vertebræ, except the cervicals.

§ 7. *Sacral vertebræ.*—Of the three vertebræ of which the sacrum of *Felis spelæa* was composed, we have only met with the last, and to it a portion of the centrum of the second with its postzygapophyses still adheres. In Felis generally the first sacral vertebra much resembles the seventh lumbar in form, as far as the anterior portion goes, but it is much wider, and the metapophyses are but slightly developed; the diapophyses are much modified into the large massive anchylosis for the ilium, which extend as high as the prezygapophyses. It is firmly anchylosed to the second vertebra, the diapophysis of this also taking part in the iliac anchylosis. The second resembles the first in general form, but it is much smaller; the metapophyses and neural spine project above the surface of the neurapophyses, being a continuation of the lumbar series. The third is remarkably like the second sacral, with the exception that the diapophyses altogether disappear, and the postzygapophyses are distinct, as in the lumbars; very large anapophyses also project backwards and outwards.

Our specimen, which is that of a young adult animal, is from Sandford Hill Cave, and is in the Taunton Museum; it is nearly perfect, except the end of the anapophyses and the neural spine. The metapophyses and their relation to the rest of the vertebra and the neural canals on each side of them are clearly seen. We can find no difference between it and that of a Lion. We have given a figure of it in our large plate of the ossa innominata from Sandford Hill Cave, which possibly may have belonged to the same animal.

§ 8. *Caudal vertebræ* (Pls. XIV, fig. 3; XVI, figs. 4—8).—We have no means of exactly ascertaining the number of these vertebræ in *Felis spelæa*, but most probably it was the same as in Lion and Tiger, and varied from twenty-three to twenty-five. They are very numerous in the caverns of Somersetshire, which have supplied us with the materials for the following description:

The five first caudals in the larger Feles closely resemble each other, and to a considerable extent the last sacral. In the living animal they are within the body, the remainder of the series being exserted. Their centra are short and concave on the ventral surface, with elliptical section and slightly convex epiphyses. The neurapophyses enclose a neural arch of considerable size, but which diminishes rapidly distally. The metapophyses, projecting upwards and proximally beyond the centrum, support well-defined but flat prezygapophyses, locking with the postzygapophyses of the preceding vertebræ, which are also well defined, and project beyond the centrum. Strong, flat anapophyses, somewhat resembling those on the third sacral, extend backwards and slightly downwards. Those on the second are the largest; those on the first expand proximally in

some specimens into flat diapophyses, which are represented by small flat tubercles on the three next vertebræ. On the first there is a rudiment of a neural spine, which subsides into a slight ridge on the rest. Hypapophysial tubercles appear on the ventral aspect of the anterior end of the second vertebra, and are continued on the rest to the end of the tail; corresponding tubercles also appear on the distal end also; these support in the living Feles on a variable number of the anterior caudals, small, triangular or rather boat-shaped bones, the caudal hæmapophyses, none of which have occurred to us in a fossil state.

These first five are distinguished from each other by the increasing length of the centra, the diminution of the neural arch, and of the size of the zygapophyses, as well as by the more circular form of the anterior epiphyses, each of these characteristics becoming more marked distally.

Of these vertebræ we have one third, one fourth, and two fifths, all from Bleadon, and one fifth from Sandford Hill. They are all rather larger than the corresponding vertebræ of average Lion, but offer no other distinguishing mark; the above general description will, therefore, suffice. We have figured the fourth (Pl. XVI, figs. 4, 4′). It will give a fair idea of the general form of these vertebræ, keeping in mind the differences indicated above, and the fact that the anterior zygapophyses and epiphyses are worn, and the post-zygapophyses lost. It is the first of a series, which, with the exception, perhaps, of the seventh, eleventh, and thirteenth, reaches to the fourteenth, and so closely correspond in size, condition, and character, that they may have all belonged to one animal.

The next three, or the first exserted vertebræ, form also a series; they differ from the first five in the greater length of the centra, the section being more or less circular anteriorly, and elliptical distally, with epiphyses highly convex; the neurapophyses are very short, and the neural canal correspondingly small, the metapophyses are more at right angles to the centrum, and less divergent vertically than on the first five, and the prezygapophyses are very small, and project less forwards, the articulations of these are also very small, and disappear on the eighth, the postzygapophyses are also minute and project less on each succeeding vertebra, till on the eighth they do not extend beyond the distal epiphysis. The notch over the neural canal between the pre-zygapophyses becomes longer, and exposes more of the neural canal distally. This appears to be more the case in the young than in the old animals.

Flat diapophysial tubercles are developed on the sixth vertebra, and are continued to the end of the tail, the anapophyses become smaller, and gradually subside to very small tubercles on the most distal vertebræ. The hypapophysial tubercles are very distinct anteriorly on the ventral surface of the centra.

We have met with three of the sixth, three of the seventh, three of the eighth, from Bleadon, and two from Sandford Hill, one of the latter being that of a young adult animal, the epiphyses being not yet firmly anchylosed. We have figured a seventh caudal from Bleadon, a perfect specimen of very large size (Pl. XIV, figs. 3, 3′, 3″, 3‴). We are doubtful about an imperfect seventh belonging to the series mentioned above, because of its large size.

With the eighth vertebra the neural canal ceases, and is represented on the rest of the vertebræ by a shallow groove on the dorsal surface of the centrum, the sides of the groove passing into diverging metapophysial and united postzygapophysial tubercles, which do not in any case project over the epiphyses. The centra of these vertebræ are more or less cylindrical, the strong di-an-apophysial ridges on the sides, the neurapophysial on the dorsal and the muscular ridges on the ventral surface, making them more or less angular at various points. The ninth is generally the stoutest (Pl. XVI, fig. 5), and the tenth (fig. 6) and sometimes the eleventh (figs. 7, 7′, 7″) is the longest of these vertebræ, which diminish in size rather rapidly to the end of the tail. The last vertebra appears sometimes to be cartilaginous in the recent Feles. The epiphyses are anteriorly nearly circular, and distally more or less quadrangular and highly convex. The metapophyses are flat plates subsiding into rounded tubercles distally, diverging and pointing slightly forwards on the ninth, but becoming more upright distally. The diapophyses and anapophyses have been described above, the hypapophysial tubercles are distinct throughout the series. The position of the vertebræ can be only fixed by comparison with a known series, and the variations of proportion of the parts are such that this comparison cannot produce absolute certainty, and the uncertainty is made greater by the great variation in size, which may be estimated from our figures of the tenth and eleventh vertebræ, the tenth being taken from the series above mentioned, which is slightly larger than that of the average lion, and the eleventh from another series of much more gigantic proportions. From the smaller series we have figured the ninth, tenth, twelfth, thirteenth, and fourteenth (Pl. XVI, figs. 5—10). We have also a series of large size from the ninth to the thirteenth, one other ninth and an eleventh besides a fifteenth, a sixteenth, a seventeenth, an eighteenth, and a small vertebra near the extremity of the tail. These determinations of place are, of course, subject to the uncertainty above expressed. The general description applies equally to all. The only difference he can see between them and those of the Lion is, that the metapophyses appear to be somewhat less divergent, but this appears to be variable, not only in Lion, but also in *Felis spelæa*. The proportions also are somewhat longer than in the Lion in most cases, but some vertebræ of the position, of which we have no doubt whatever, appear to be somewhat shorter.

Measurements of Atlas. (In Inches.)	*Felis spelæa.* Sandford Hill	*Felis leo.*
1. Minimum height of neural arch	1.27	1.00
2. Width of neural arch at tubercles for transverse ligament	1.15	0.98
3. Zygapophysial length	3.32	2.75
4. Maximum width of prezygapophysis (external)	3.26	2.58
5. Width of the same at the edge of the glenoid articulation	2.54	2.20
6. Width of the postzygapophyses	3.40	2.70
7. Minimum proximo-distal length of neurapophyses	1.59	1.30

Table of Measurement of Vertebræ. (In Inches.)	Fourth Cervical.			Fifth Cervical.		Sixth Cervical.		
	Felis leo.[1]	*Felis spelæa.* Bleadon.	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Bleadon.	*Felis spelæa.* Sandford Hill,
1. Length of centrum	1.44	1.44	1.62	1.40	1.68	1.45	...	1.50
2. Anterior depth of centrum	0.86	0.92	1.12	0.86	1.15	0.88	1.10	0.95
3. Posterior depth of centrum	0.92	0.94	1.18	0.97	...	1.04	...	1.05
4. Anterior width of centrum	1.36	1.45	1.65	1.36	1.60	1.38	...	1.40
5. Posterior width of centrum	1.44	1.52	...	1.50	...	1.40	...	1.44
6. Minimum height of neural arch	0.50	0.78	0.64	0.50	0.65	0.55	0.70	0.69
7. Minimum width of neural arch	0.84	0.92	0.95	0.95	1.00	1.08	0.94	1.09
8. Anterior width of pleurapophysis	2.30	...	...	2.45	...	3.32	...	...
9. Posterior width of pleurapophysis	3.60	...	...	3.55	...	2.45	...	2.50
10. Length of pleurapophysis	1.15	...	...	1.50	...	2.28	...	...
11. Maximum width of diapophysis	3.69	...	...	3.60	4.80	3.90	...	4.00
12. Zygapophysial length	2.50	..	2.54	2.24	2.85	2.12	2.33	2.00
13. Anterior zygapophysial width	3.03	...	...	2.95	3.60	2.71	3.22	2.35
14. Posterior zygapophysial width	2.75	...	3.04	2.72	...	2.75	...	2.70
15. Height of neural spine	0.90	...	...	0.87	...	1.16	...	1.40

[1] The vertebræ of the lion used in their measurement are those of a specimen of average size in our own possession.

	First Dorsal.			Second Dorsal.		Seventh Dorsal.		Eighth Dorsal.	
	Felis leo.	*Felis spelæa.* Bleadon.	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Sandford Hill.	*Felis leo.*	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Bleadon.
1. Length of centrum	1.30	1.30	1.44	1.28	1.34	1.25	1.54	1.30	1.62
2. Anterior depth of centrum	1.00	1.05	1.28	1.00	1.18	1.00	1.27	1.06	1.20
3. Posterior depth of centrum	1.00	1.05	1.28	0.95	1.05	1.00	1.27	1.05	1.17
4. Anterior width of centrum	1.70	2.05	2.43	1.85	1.94	1.30	1.60	1.31	1.70
5. Posterior width of centrum	1.60	1.82	2.42	1.70	1.94	1.70	2.18	1.75	1.82
6. Minimum height of neural arch	0.62	0.55	0.70	0.60	0.63	0.57	0.70	0.65	
7. Minimum width of neural arch	1.00	1.00	1.22	0.85	0.94	0.60	0.83	0.64	
8. Anterior pleurapophysial width									
9. Posterior pleurapophysial width									
10. Length of pleurapophysis									
11. Maximum width of diapophysis	3.57	...	...	3.25	3.35	2.55	3.20	2.50	
12. Zygapophysial length	1.90	...	...	1.90	2.25	2.05	2.50	2.00	
13. Anterior zygapophysial width	2.65	2.73	3.02	2.24	2.25	0.92	1.25	0.90	
14. Posterior zygapophysial width	2.25	...	...	1.55	1.67	0.92	1.05	0.85	1.30
15. Height of neural spine	2.50	...	...	3.30	4.30	3.50	...	3·45	

	Eleventh Dorsal.		Thirteenth Dorsal.		Second Lumbar.			Third Lumbar.	
	Felis leo.	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Sandford Hill.	*Felis leo.*	*Felis spelæa.* Sandford Hill.	*Felis spelæa.* Sandford Hill.	*Felis leo.*	*Felis spelæa.* Sandford Hill.
1. Length of centrum	1·35	1·70	1·50	...	1·90	2·15	...	1·95	...
2. Anterior depth of centrum	1·22	1·45	1·00	...	1·03	1·35	...	1·15	1·28
3. Posterior depth of centrum	0·92	1·35	1·10	...	1·03	1·30	1·30	1·15	...
4. Anterior width of centrum	1·26	1·65	1·45	1·92	1·58	1·93	1·90	1·64	2·00
5. Posterior width of centrum	1·63	2·20	1·75	...	1·74	1·92	...	1·74	...
6. Minimum height of neural arch	0·50	0·66	0·50	0·61	0·50	0·52	0·62	0·54	0·64
7. Minimum width of neural arch	0·58	0·83	0·68	0·91	0·75	0·78	0·87	0·75	1·10
8. Anterior pleurapophysial width	...	...	...	...	...	...	...	...	...
9. Posterior pleurapophysial width	...	...	...	...	...	...	...	...	...
10. Length of pleurapophysis	...	...	...	...	...	...	...	...	...
11. Width of diapophysis	2·50	3·25	1·85	...	2·90	3·64	...	3·42	...
12. Zygapophysial length	2·30	2·58	2·75	2·74	3·05	3·33	...	3·00	...
13. Anterior zygapophysial width	1·25	1·44	0·85	1·34	1·00	1·27	1·25	1·35	1·43
14. Posterior zygapophysial width	1·05	1·43	0·80	1·20	1·28	1·24	...	1·35	...
15. Height of neural spine	1·89	1·56	1·40	...	1·44	...	...	1·60	...
16. Width of metapophysis	...	...	1·70	1·84	1·95	2·00	1·65	2·20	1·98
17. Width of anapophysis	...	...	1·95	2·35	1·90	2·06	...	1·35	...
18. Distance from ana- to metapophysis	...	...	2·50	2·81	2·75	2·90	...	1·55	...

	Fourth Lumbar.		Fifth Lumbar.		Sixth Lumbar.			Seventh Lumbar.	
	Felis leo.	*Felis spelæa.* Sandford Hill.	*Felis leo.*	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Sandford Hill.	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Bleadon.
1. Length of centrum	2·03	...	2·20	2·96	2·25	...	2·40	1·95	2·10
2. Anterior depth of centrum	1·25	1·53	1·36	1·60	1·40	1·30	1·30	1·29	1·42
3. Posterior depth of centrum	1·25	...	1·20	1·54	1·30	1·40	1·25	1·29	1·33
4. Anterior width of centrum...... ..	1·65	2·04	1·72	2·15	1·95	2·10	2·05	1·95	2·09
5. Posterior width of centrum	1·83	2·00	1·90	2·33	1·92	2·20	2·05	1·95	2·20
6. Minimum height of neural arch...	0·55	0·55	0·55	...	0·46	0·50	0·50	0·40	0·50
7. Minimum width of neural arch ...	0·85	1·10	1·00	1·22	0·92	1·12	1·20	1·00	1·08
8. Anterior pleurapophysial width...	...	...	...	...	...	...	...	...	...
9. Posterior pleurapophysial width...	...	...	...	...	...	...	...	...	...
10. Length of pleurapophyses	...	...	...	...	...	...	...	...	...
11. Width of diapophyses	4·10	...	4·90	...	5·60	...	...	5·70	...
12. Zygapophysial length..............	3·10	3·53	3·20	...	2·90	3·65	3·30	2·65	...
13. Anterior zygapophysial width ...	1·40	1·45	1·45	...	1·36	1·57	1·44	1·55	...
14. Posterior zygapophysial width ...	1·30	1·35	1·40	...	1·50	1·20	1·72	2·66	3·10
15. Height of neural spine	1·30	...	1·84	...	1·84	...	...	1·74	...
16. Width of metapophyses	2·22	...	2·05	...	2·10	2·00	...	2·18	...
17. Width of anapophyses	1·90	...	1·80	...	1·70	2·02	2·00	...	...
18. Distance from ana- to metapophyses	2·58	...	2·43	...	2·00	2·45	2·30	...	...

	Third Sacral.		Third Caudal.		Fourth Caudal.		Fifth Caudal.		
	Felis leo.	*Felis spelæa.* Sandford Hill. Figured.	*Felis leo.*	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Bleadon. Figured.	*Felis leo.*	*Felis spelæa.* Bleadon.	*Felis spelæa.* Bleadon.
1. Length of centrum	1·00	1·30	1·20	1·35	1·26	1·50	1·40	1·60	1·67
2. Anterior depth of centrum.........	0·67	0·80	0·78	0·80	0·76	0·86	0·76	0·80	0·87
3. Posterior depth of centrum	0·85	0·75	0·76	0·80	0·72	0·83	0·70	0·74	0·80
4. Anterior width of centrum	1·00	1·18	1·00	1·05	0·94	0·95	0·85	0·90	1·05
5. Posterior width of centrum	1·10	1·05	1·10	1·15	1·10	1·10	1·00	1·05	1·20
6. Minimum height of neural arch	0·25	0·35	0·21	0·22	0·15	0·17	0·20	...	0·20
7. Minimum width of neural arch	0·60	1·22	0·35	0·40	0·25	0·25	0·25	...	0·25
11. Width of diapophyses..............	...	...	2·08	2·40	1·70	2·25	1·45	1·30	...
12. Zygapophysial length...	1·70	1·82	1·76	...	1·75	...	1·90	...	...
13. Anterior zygapophysial width......	1·10	0·80	0·96	0·80	0·75	0·90	0·70	...	0·80
14. Posterior zygapophysial width ..	0·85	1·18	0·70	...	0·70	...	0·60	...	...
15. Height of neural spine	0·75	...	...	...	...	...	...	...	...
16. Width of metapophyses	1·25	1·14	1·32	1·20	1·20	1·20	1·27	...	1·30
17. Width of anapophyses..............	3·15	...	2·45	2·40	2·35	2·80	2·15	...	...
18. Distance from ana- to metapophyses	1·75	...	2·00	...	2·10	2·25	2·00	...	...
19. Minimum circumference...........	...	...	3·50	3·45	3·10	3·50	2·80	2·85	3·20

	Sixth Caudal.			Seventh Caudal.			Eighth Caudal.			
	Felis leo.	*Felis spelæa.* Bleadon.	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Sandford Hill.	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Sandford Hill.	*Felis spelæa.* Bleadon.	*Felis spelæa.* Bleadon.
1. Length of centrum..................	1·70	1·75	2·00	1·80	1·95	2·00	2·15	2·00	2·20	2·00
2. Anterior depth of centrum.........	0·75	0·75	...	0·85	...	0·89	0·88	0·80	0·85	0·85
3. Posterior depth of centrum	0·80	0·76	0·83	0·80	0·70	0·78	0·85	0·75	0·88	0·75
4. Anterior width of centrum.........	0·90	0·88	...	0·90	...	0·98	0·90	0·85	1·00	0·87
5. Posterior width of centrum	1·00	1·00	1·10	1·00	...	1·12	0·95	1·10	1·20	1·09
6. Minimum height of neural arch...	0·16	...	0·18	0·10	0·12	0·10	0·07	0·10	0·08	...
7. Minimum width of neural arch...	0·19	...	0·21	0·14	0·15	0·18	0·12	0·12	0·12	...
11. Width of diapophyses..............	1·12	1·20	...	1·30	1·20	1·50	1·32	1·42	1·25	1·20
12. Zygapophysial length..............	2·00	...	...	2·03	...	2·40	1·83	1·75	...	2·27
13. Anterior zygapophysial width ...	0·63	0·80	0·65	0·64	0·70	0·80	0·50	0·50	0·50	0·50
14. Posterior zygapophysial width ...	0·52	...	...	0·40	...	0·40	0·35	0·30	...	0·20
15. Height of neural spine	...	...	...	...	...	...	...	...	...	...
16. Width of metapophyses	1·20	1·40	1·10	1·13	0·90	1·30	0·87	0·82	0·82	0·85
17. Width of anapophyses	1·90	1·90	...	1·64	1·70	2·00	1·45	1·42	1·78	1·80
18. Distance from ana- to metapophyses	2·05	2·30	...	2·15	2·15	2·50	2·25	1·95	2·24	2·21
19. Minimum circumference...........	2·80	2·85	3·20	2·65	2·60	3·20	2·40	2·30	2·75	2·70

	Ninth Caudal.				Tenth Caudal.			Eleventh Caudal.	
	Felis leo.	*Felis spelæa.* Bleadon.	*Felis spelæa.* Bleadon.	*Felis spelæa.* Bleadon. Figured.	*Felis leo.*	*Felis spelæa.* Bleadon.	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Bleadon. Figured.
1. Length of centrum	2·15	2·12	2·60	2·25	2·30	2·65	2·40	2·10	2·45
2. Anterior depth of centrum	0·90	0·78	1·10	0·88	0·90	0·90	0·90	0·75	0·90
3. Posterior depth of centrum	0·80	0·70	0·84	0·70	0·70	0·85	0·80	0·60	0·90
4. Anterior width of centrum	0·75	0·85	1·10	0·75	0·80	0·90	0·80	0·70	0·95
5. Posterior width of centrum	0·90	0·93	1·20	0·90	0·90	1·00	0·93	0·80	1·00
6. Minimum height of neural arch	...	...	...	...	...	...	...	...	...
7. Minimum width of neural arch	...	...	...	...	...	...	...	...	...
11. Width of diapophyses	1·20	1·25	1·80	1·10	1·25	1·20	1·40	1·15	1·50
12. Zygapophysial length	...	..	...	...	...	...	...	...	...
13. Anterior zygapophysial width	...	...	...	...	...	...	...	...	...
14. Posterior zygapophysial width	...	...	...	...	...	...	...	...	...
16. Width of metapophyses	0·80	0·80	0·85	0·65	0·60	0·80	0·70	0·70	0·30
17. Width of anapophyses	1·20	1·40	...	1·35	1·15	1·60	1·18	1·00	1·35
18. Distance from ana- to metapophyses	2·00	1·80	2·40	2·00	2·10	2·40	2·20	1·95	2·40
19. Minimum circumference	2·40	2·20	2·85	2·15	1·90	2·50	1·90	1·75	2·30

	Twelfth Caudal.				Thirteenth Caudal.			Fourteenth Caudal.	
	Felis leo.	*Felis spelæa.* Bleadon.	*Felis spelæa.* Bleadon.	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Bleadon.	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Bleadon.
1. Length of centrum	2·10	2·30	2·30	2·10	2·00	2·20	2·25	1·80	1·95
2. Anterior depth of centrum	0·80	0·90	0·80	0·75	0·70	0·80	0·80	0·60	0·60
3. Posterior depth of centrum	0·75	...	0·80	0·60	0·62	0·70	...	0·55	0·55
4. Anterior width of centrum.........	0·70	0·80	0·82	0·70	0·60	0·85	0·80	0·54	0·68
5. Posterior width of centrum	0·70	...	0·80	0·70	0·60	0·75	...	0·50	0·60
11. Width of diapophyses...............	1·10	...	...	1·10	1·15	1·25	0·10	0·84	1·05
16. Width of metapophyses............	0·52	...	0·70	0·50	0·65	0·60	0·60	0·54	0·55
17. Width of anapophyses	0·96	...	1·25	1·00	0·85	1·20	...	0·70	0·75
18. Distance from ana- to metapophyses	2·05	...	2·30	2·00	1·95	2·15	2·10	1·70	1·90
19. Minimum circumference	1·60	2·15	2·25	1·80	1·50	1·80	1·85	1·30	1·50

	Fifteenth Caudal.		Sixteenth Caudal.		Seventeenth Caudal.		Eighteenth Caudal.		Twentieth, or Twenty-first Caudal.	
	Felis leo.	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Bleadon.	*Felis leo.*	*Felis spelæa.* Bleadon.
1. Length of centrum	...	...	1·55	1·95	1·45	1·75	1·20	1·40	0·70	1·00
2. Anterior depth of centrum	0·50	0·60	0·50	0·55	0·48	0·55	...	...	...	...
3. Posterior depth of centrum	...	...	...	...	0·49	0·50	...	...	...	...
4. Anterior width of centrum	...	...	0·52	0·60	0·46	0·50	...	...	...	...
5. Posterior width of centrum	...	...	...	...	0·43	0·53	...	...	...	...
16. Width of metapophyses	0·45	0·50	...	...	...	...	...	...	...	...
18. Minimum circumference	1·20	1·30	1·12	1·40	1·08	1·30	1·00	1·10	0·80	0·75

§ 10. *Literature.*—We know of the following figures of the vertebræ of *Felis spelæa.* M. Schmerling, 'Oss. Foss. de Liége,' a mutilated atlas, tom. ii, pl. xvii, fig. 14; a first dorsal, pl. xviii, fig. 1; a sixth lumbar, figs. 2 and 3; an entire sacrum, pl. xvi, fig. 1; a fourth caudal, pl. xviii, fig. 4; an eighth caudal, fig. 5; and one of the smaller caudals, fig. 6. These are all of large size. The under side of a second sacrum, of the size of that of the lion, is in the figure of the entire pelvis, in pl. xix, fig. 2.

MM. Marcel de Serres, Dubrueil, and Jean Jean ('Oss. Foss. de Lunel Viel') figure the tenth dorsal (?), pl. viii, fig. 7; the second and third lumbars, fig. 8; the entire sacrum, under side, fig. 9; a second sacrum rather smaller than that of the lion, fig. 15; a fourth caudal, fig. 13; and a smaller cylindrical caudal, fig. 14.

§ 11. *Sternum.*—The number of sternebers in the genus Felis, including the manubrium and xiphoid, is eight, as is usually the case with the Carnivores generally. Some species, however, such as the Glutton, have nine. We do not describe the manubrium or xiphoid, as we have met with no fossil specimens of either. The intermediate sternebers are more or less rectangular in form, flat, or slightly concave on the ventral surface, flat or slightly convex vertically on the sides, and rounded on the inferior or thoracic surface, which is traversed by a slight, irregular keel, bifurcating distally like the letter Y. They are smaller in the middle than at their ends, which are roughened for the cartilaginous epiphyses, to which the ribs are attached. Sometimes the epiphyses are wanting, and, as in a lion in our own possession, two or more sternebers may be anchylosed together. They are distinguished from each other by their proportions. The anterior or second is the longest, most compressed, and deepest, and the seventh, or that next the xiphoid, is the shortest, widest, and most depressed. The intermediate bones present a regular gradation from the one to the other of these forms.

There is a very great variation observable in the size and form of these bones when two or more individuals are compared together, even of the same species of *Felis;* and they seem to be abnormally affected by captivity. Those of the lion for the most part are more depressed than those of the tiger, and the latter more so than those of the jaguar. It is, therefore, difficult if not impossible to ascertain with absolute accuracy the exact position of any given feline sterneber unless the whole series from one animal is perfect.

We cannot, therefore, accurately determine any of the fossil sternebers. We have met with four perfect and one imperfect feline sternebers in the Taunton Museum; they were obtained from Bleadon Cave. They do not exactly resemble those of any lion or tiger with which they have been compared, being longer than in those animals, and the shortest presenting the same proportion as the longest of those of the tiger. Three of them assume the proportions of the third, fourth, and sixth of a small jaguar in our possession, though they exceed the corresponding bones of a large tiger in size; the remaining two, of somewhat smaller dimensions, also assume the proportions of the fourth and fifth of the jaguar. Their large size, indeed, is the only point that separates them from those of that animal. They are

distinguished from those of the bear by the greater compression, more rounded section, and smaller length in the latter animal. The texture of the bone also affords a character by which they may be distinguished, being much more compact in the cave lion than in the bear. We have given a figure of the sterneber which we consider to be the third (Pl. XVI, fig. 10, 10[1]). Among the bones of the lion which Sir Philip Egerton, F.R.S., and Lord Enniskillen, F.R.S., obtained from Gailenreuth Cave, was a feline sterneber exactly agreeing with our figure.

The following measurements show the relations that they bear to those of lion and jaguar.

	Third Sterneber.			Fourth Sterneber.			
	Felis spelæa. Bleadon.	*Felis leo.* W. A. S.	*Felis jaguar.* W. A. S.	*Felis spelæa.* Bleadon.	*Felis spelæa.* Bleadon.	*Felis leo.* W. A. S.	*Felis jaguar.* W. A. S.
Length	1·70	1·30	1·05	1·50	1·40	1·30	1·00
Maximum anterior depth...	1·10	1·00	0·60	1·20	1·00	1·05	0·55
Maximum anterior width	0·90	1·05	0·50	1·05	0·78	1·10	0·50
Maximum posterior depth	1·20	0·90	0·55	1·15	0·98	1·10	0·50
Maximum posterior width	1·10	1·30	0·50	1·00	0·85	1·10	0·53
Minimum circumference ...	2·48	2·60	1·12	2·70	2·50	2·60	1·30

	Fifth Sterneber.			
	Felis spelæa. Bleadon.	*Felis spelæa.* Bleadon.	*Felis leo.* W. A. S.	*Felis jaguar.* W. A. S.
Length	1·50	1·50	1·20	0·92
Maximum anterior depth ...	1·10	1·00	0·90	0·52
Maximum anterior width...	0·80	...	1·05	0·50
Maximum posterior depth...	1·00	1·00	0·85	0·50
Maximum posterior width...	1·10	...	1·30	0·56
Minimum circumference ...	2·90	...	2·50	1·28

CHAPTER IX.

Scapula. Pl. XVII.

CONTENTS.

§ 1. *Introduction.* | § 2 *Description.*
§ 3. *Measurements.*

§ 1. *Introduction* (Pl. XVII).—The original of the figures in this plate is the least mutilated of a pair of scapulæ which, from their condition, we consider to have belonged to the same animal as many of the bones in the Taunton Museum belong, such as the skull (Pls. VI, VII, VIII, IX), the jaws (Pl. X), the radius (Pl. II, fig. 1), and many others, which will be enumerated at the end of this Monograph. The condition of the epiphyses and muscular impressions proves that, although the animal had reached its full growth, it died before the ossification was completed in all parts. With the exception of a mutilated fragment from Bleadon Cavern, and an equally imperfect piece of one belonging to a whelp from the Mendip Cave, we know of no other British specimens: it appears to be equally rare on the Continent. Its rarity may perhaps arise from its fragile character.

In fig. 1 we have represented the glenoid cavity (*a*), the distal edge of the spine (*c*), the acromial process (*f*), with the overlapping lamina, which we term, from the name of the muscle to which it gives attachment, the delto-acromial process (*g*). The extent also is shown to which axillary border (*i*) extends beyond the plane of the inferior and posterior edge of (*a*), as well as the base of coracoid process (*d*), the point of which is broken away. Fig. 2 represents the superior or outer surface. The anterior and upper or vertebral portion of the bone, and the upper third of the spine, are broken away, leaving the glenoid cavity (*a*), the lower part of the spine (*f* and *g*), the axillary border (*i*), up to the insertion of the teres major muscle, and the greater part of the infra-spinal surface (*e*), n a very perfect state.

§ 2. *Description. Glenoid Cavity.*—(*a*). The inferior angle of the scapula is truncated to form the glenoid cavity, which is slightly concave transversely, deeply so longitudinally, oval in outline, with the long diameter lying parallel to the median line. In the figured specimen the periphery is nearly even with the surface of the cavity; but in an older fragment from Bleadon it is slightly raised, so as to form a rim somewhat thicker behind than before. It gives attachment to a ring of fibro-cartilage, that considerably deepened the cavity for the humerus, and afforded a greater freedom of motion to the fore limb than if it had been completely ossified. On the upper or outer edge is a depression which destroys the completeness of the oval (*n*), corresponding with the deltoid process of the humerus: this depression is a point of difference between the scapulæ of Lions and Bears. The anterior contour of the oval is broken by the prolongation of a ridge, passing from the base of the coracoid (*d*). This ridge and the process supporting it descend further in Felis than in Ursus, rendering the glenoid cavity far more concave longitudinally in the former than in the latter. The broadly oval form also differentiates the feline glenoid from the narrow and elliptical one of Ursus, and from the triangular and smaller one of Hyæna.

Coracoid.—(*d*). The body of the coracoid completely soldered to the scapula forms a portion of the broad obtuse process (*b*), on the anterior edge of the glenoid cavity. Its point is broken in the specimen figured, but its position is marked by the ridge passing from it to the edge of the glenoid cavity. The process (*b*) affords attachment to the tendon of the biceps muscle.

Neck.—The coracoidal and glenoidal portions of the bone are separated from the rest by a well-defined constriction or neck, the existence of which affords a good character for determining feline scapulæ from those of Bears.

Dorsal or superior surface.—The superior surface is divided into two subequal parts by the spine (*c*), the upper of which is the supra-spinal (*m*), the lower the infra-spinal fossa (*e*). The portion of the scapula figured is very slightly concave in the first of these, and slightly convex in the second, and so far resembles that of a Lion in our own possession. Its fragmentary condition prevents any minute comparison with that of the Lion and Tiger. In the two Lions in the College of Surgeons the convexity of (*e*) varies in degree, while in the Tiger it is barely perceptible.

Spine (*c*).—The spine more prominent than that of Bear, springing at right angles to the body of the bone, and passing obliquely backwards from the neck to the anterior angle of the vertebral or upper border, divides, as above stated, the two fossæ. It slightly increases in height from the acromion to the middle of the delto-acromial process, and thence declines to the periphery of the bone. This latter portion, however, is broken in the figure. The acromion (*f*), which in the figured bone is imperfectly ossified, is rounded, very slightly inclined forwards, and does not articulate with the rudimentary clavicle, which is also without a sternal articulation. In the old animal it would overhang but a small part of the glenoid cavity, and it does not extend down to a plane passing

through its anterior and posterior edges. In the Bears it projects beyond this, and in the Hyænas it does not overhang any portion of the glenoid cavity. Behind the acromion the spine gradually throws off a laminar process (*g*) at right angles to itself, scalene-triangular in outline that overhangs the infra-spinal fossa, and affords attachment to the transverso-scapular and delto-acromial muscles. This delto-acromial process affords an excellent means of determining the scapula of the Carnivores. In the Subursines, Glutton, Badger, and the like, it is nearly of the same form as in Felis; in Canis and Hyæna it is much smaller and less strongly defined, while in the Bear it is replaced by a broad massive process extending nearly equally on both sides of the spine. The development and form is closely connected with the rapid and free movement of the fore limb. The spine gradually recovers its verticality at a point about two inches from the acromion.

The infra-spinal fossa (*e*), bounded anteriorly by the spine, and posteriorly by the axillary border (*i*), is a broad smooth triangular surface, slightly concave inferiorly, slightly convex above, occupied for the most part by the infra-spinatus muscle. The degree of curvature varies in the Lions, and is reduced to nothing in the Tigers. The strong axillary border (*i*) is well rounded on the outer surface, sharp on the extreme edge, and concave on the inner surface. It bears impressions for the attachment of muscles through its whole length, though from its having belonged to a comparatively young animal they are hardly so sharply defined as in the older bones. They form an irregular line of small tubercles (*i*) running from the neck of the bone and dying away as they reach the level of the insertion of the teres major muscle. They represent the linea obliqua of human anatomy, which is extremely prominent in the Bear and recent Lion: while it is rounded in the Tiger. It gives attachment to the teres minor muscle: that of the teres major occupies precisely the same position in the figured scapula as in Lion and Tiger, being situated on the inner edge of the upper portion of the axillary border, and must not be confounded with the strongly-marked impression, at nearly the same level on the outer border, which belongs to the superior portion of the teres minor (*h*).

Internal surface.—The internal surface is for the most part smooth, and without strongly marked ridges. The lower two thirds are longitudinally convex, while the upper third is slightly concave; from the glenoid cavity to the insertion of the teres major the convexity gradually increases, so as to form a well-defined border to the smooth and nearly flat area, which extends to the part immediately underlying the spine, which is concave. We do not figure this surface, because it presents no characters of importance.

§ 3. *Measurements.*—The superior size of the Spelæan Lion, as compared with the living Lion and Tiger, is shown in the following table.

The long diameter of the glenoid cavity of a spelæan scapula from the caverns of Liège, given by Dr. Schmerling is 2·6 inches, the short 1·8 inches.

TABLE OF MEASUREMENTS.

Measurements of Scapulæ.	*Felis spelæa.* Figured.	*Felis spelæa.* Sandford Hill.	*Felis spelæa.* Bleadon.	Lion. W. A. S.	Lion. Col. Surg.	Lion. Col. Surg.	Tiger. Col. Surg.
Length of scapulæ	...	...	...	10·00	11·30	9·00	9·00
Circumference at neck	6·55	6·60	7·00	5·70	5·78	4·80	5·00
Length of glenoid cavity	3·00	...	3·00	2·25	2·20	1·90	2·10
Width of glenoid cavity	2·30	2·28	...	2·10	1·80	1·40	1·40
Length of axillary border to insertion of teres muscle (h)	6·30	...	...	5·30	...	...	...
Entire length of teres muscle	...	...	...	8·50	8·90	7·50	5·30
Breadth at impression for teres (h)	0·40	...	...	0·30	0·00	5·30	...
Height of spine from surface	2·25	...	...	2·00	...	...	...
From acromion to surface of glenoid cavity	1·10	1·00	0·90	0·60	...	...	...

CHAPTER X.

Humerus. Pl. XVIII, figs. 1, 2, 3.

CONTENTS.

§ 1. *Introduction.* | § 2. *Description.*
§ 3. *Measurements.*

§ 1. *Introduction.*—The well-known inverse proportion which is found to exist in all animals between the lengths of the humeri and metacarpals is well exemplified in the comparison of the larger with the smaller Feles. In the smaller animals of the genus the metacarpals are comparatively short, and the humeri long: in the larger, both are of moderate length, and, as may be expected, of immense strength.

The fossil humeri of Felis are only known in Britain by fragments. At Gailenreuth, however, the perfect bone has been found by Sir Philip Egerton and Lord Enniskillen, and a cast of it is preserved in the British Museum. The well-known figure also of the humerus found by Dr. Schmerling in the cavern of Liége enables us to estimate proportions of the entire bone in *Felis spelæa*. This we have copied in light tint in our figure (fig. 1), and on it we have represented in a darker tint the distal portion of a slightly darker specimen from Bleadon Cave (fig. 1, *c′m*); and on this again we have drawn a large part of a shaft from Oreston Cave, in the British Museum (*d, e*), which offers some peculiarities to be described presently; and finally, in full tint, we give the proximal articulation (*a, a′*), and the distal ends (*f, f′, m*) of large specimens from Bleadon. In this way we have completed, so far as the materials at our disposal allow, a figure of the posterior aspect of the humerus from British specimens.

The figure of the anterior aspect of the distal end (fig. 2) is taken from a specimen in the possession of the Rev. H. H. Winwood, found in the river-gravel at Larkhall, near Bath, and that of the distal articulation (fig. 3) is from the largest specimen we have met with from Sandford Hill Cavern.

M. de Blainville states that the humeri of the Tiger are wider distally than those of

the Lion ; but the variations in this respect in the skeletons of the animals which we have examined in the British collections is so great that we cannot admit the specific value of this distinction, and therefore we cannot assert that the average specimens of the fossil humeri approach one species more than another. Singularly enough, however, the two most perfect shafts we have seen differ considerably from those of any recent Felis in their extreme antero-posterior compression, especially that from Oreston (fig. 1, *c*, *d*).

The compression of the Gailenreuth specimen is not so evident. In the large fragment (*c*, *c'*) we have figured from Bleadon, and in that of Dr. Schmerling (fig. 1, light tint), there is no evidence of it whatever, and the many fragments we have met with show that the general proportions of the shaft were those of the recent Lion or Tiger. Some are intermediate between the compressed and the ordinary form, and connect the two extremes together. In the absence, therefore, of any other evidence of a second large species of Felis in the Pleistocene deposits of Britain and Germany, we refer the compressed humeri to a somewhat abnormal form of the spelæan Lion. The comparison of a large series of bones of the same species, either recent or fossil, shows that no particular bone is cast in a crystalline form, but that the variations increase in proportion to the number examined. How far this may go on without transgressing the limits of a species depends obviously upon the judgment of the naturalist. If he believe that a species has an actual existence in nature, he will look upon these variations as of specific value, because they depart from the typical form, which he will take to be as invariable as the figure of a crystal. If, on the other hand, he view a species as a mere arbitrary summing up of points of agreement devised by man for the classification of the varied forms of life, he will consider that the variations are simply the result of a more minute inquiry, and he will extend the limits of his species to cover a very large amount of variation. Few naturalists have recognised the amount of variation from a specific type, observable in many individuals, on account of the immense labour required in the investigation. As we hold the latter of these views, we consider that the compressed humerus is a mere variation from the ordinary spelæan form.

§ 2. *Description.*—The lateral aspect of the humerus is somewhat sigmoid, the proximal end being bent slightly backwards, the distal slightly forwards. It is more or less compressed proximally, and depressed distally, flat internally, and highly convex externally; the proximal articulation (fig. 1 *a*, *a'*) is of considerable size, highly convex posteriorly and internally, slightly concave close to the greater tuberosity (*b*). Its generally convex outline is intercepted anteriorly close to the bicipital groove by a roughened space devoid of synovial membrane, even with the surface of the articulation; posteriorly it overhangs the shaft, internally it is bounded by the lesser tuberosity of a reniform mass, longer than broad, and extending from behind diagonally upwards to the level of the highest part of the articulation, to which was attached the tendon of the sub-

scapularis muscle. Externally it is bounded by the greater tuberosity (*b*), a massive ridge much more elevated than in the Bear, but less so than in the Hyæna. To the external edge of the latter were attached the tendons of the supra- and infra-spinatus muscles, to the internal and anterior edge the tendon of the muscle called by Strauss-Durkheim the sterno-trochiterian,[1] which represents a portion of the pectoralis major in man, though it differs considerably from that muscle in position and office. To the posterior portion of the same tuberosity was attached the small rotundus minor, that along with the infra-spinatus acts as the rotator of the limb in an outward direction. Immediately within the free edge of the tuberosity is a supplementary process directed inwards, with its greatest diameter downwards forming the outer edge of the bicipital groove, which is deep and large, and bounded on the inner side by the projecting anterior portion of the lesser tuberosity. These edges are joined in the living animal by a very strong ligament, forming a closed canal furnished with a synovial membrane, through which plays the upper tendon of the single muscle analogous to the biceps of human anatomy.

A sharp ridge (*h*) bounds the lesser tuberosity inferiorly and posteriorly, and forms the internal edge of the posterior proximal surface of the bone. A rounded ridge descends from the articulation on the outer side of the same surface, forming, together with *h*, a broad and deep depression, into which is inserted the first head of the anconeus medius of Strauss-Durkheim, a muscle which has no analogue in man, but which in Felis aids the triceps medius in the extension of the fore-arm. The flat internal surface on the upper half of the shaft affords a broad attachment for the aponeurosis of the two branches of the latissimus dorsi, between them for the teres muscle, and above the latter for the coraco-brachial muscle. The deltoid space is a large triangular roughened surface on the convex outer portion of the bone, the base being formed by the greater tuberosity, and the apex situated at a distance from the proximal end of rather more than two fifths of the entire length of the bone, being the result of the union of the anterior and posterior deltoid ridges. Of these the former is the proximo-anterior edge of the bone, and affords attachment to the pectoralis major; the latter, situated on the antero-external surface at a lower level, afford insertion to the brachialis muscle. These ridges after their fusion pass downwards for a short distance, and turning outwards gradually die away on the external surface of the bone. To the upper and posterior portion of the deltoid space is attached the delto-spinal, to the anterior and lower the delto-acromial muscles. Immediately behind the proximal end of the posterior deltoid ridge there is a slightly roughened surface, which affords attachment to the head of the triceps externus. The proximal portion of the Feline humerus may be differentiated from that of the Bear by the presence of the following characters in the latter animal:—The deltoid space is much larger, the ridges much more strongly developed, the tuberosity is smaller, and the shaft is not so

[1] 'Anat. du Chat,' vol. ii, p. 337. He terms the greater tuberosity the trochiter and the lesser the trochin.

compressed. The distal end can generally be recognised by the large perforation of the inner condyloid crest at a slight distance above the articulation (figs. 1, 2 *i*). This character, however, is also found abnormally in some few of the humeri of Bears that are found side by side with *Felis spelæa.* The part, therefore, must be described minutely, to prevent the two species from being confounded. Immediately below the deltoid ridge the spelæan shaft is cylindrical, and then throws out the broad flat externo-condylian (figs. 1, 2, *m*, *e*) ridge on the postero-external aspect that extends to the external condyle. It affords insertions, as in Man, to the heads of the following muscles: anteriorly to the extensor carpi radialis longior and brevior, the first and second radials, which are not fused together as in Man; posteriorly to the extensor communis digitorum, and laterally to the supinator brevis; superiorly to the supinator longus, and posteriorly and on the inner side of the ridge passing diagonally upwards from the crest to the anconeus externus. The condyles are of moderate size, the external (figs. 1, 2, 3 *l*) projecting but slightly beyond the articulation, and the internal (figs. 1, 2, 3 *l'*) being by far the more prominent of the two; it is, however, far less prominent than in the Bear, and proportionally even than in Man.

The internal condylian crest is, as we have before stated, pierced by a large foramen (figs. 1, 2 *i*), directed diagonally forwards and downwards for the passage of the ulnar nerve and artery. The abutments, as it were, of the bony arch are generally found in the Bears, and sometimes in the Hyæna, the key of the arch in that case being formed by a ligament. In the former animal, however, where the arch is completed by a deposit of osseous matter, it is much nearer the distal end of the bone, and is much thinner than in *Felis spelæa.* This difference, together with the greater breadth of the distal end and the large size of the internal condyle, will sufficiently distinguish the distal portion of the humerus of Bear from that of the larger Feles.

The anconeus internus is inserted on the posterior portion of the arch. The large space occupied by the insertions of the three muscles bearing this name, indicates the enormous power of extension of fore-limb, which enables the larger Feles to use their paws with such destructive effect.

The external condyle affords insertions to the following muscles: the extensor minimi digiti, and the external ulnar; the internal to the sublimis, the pronator teres, the palmaris longus, ulnaris externus, and profundus muscles.

The articulation (figs. 1, 2, 3 *f*, *f'*) somewhat resembles that of the Bear, but it is broader transversely and thicker, and the trochlear portion (figs. 1, 2, 3 *f*, *l*, *k*) is less excavated. The latter is distinguished from the capitellar portion (figs. 1, 2, 3 *f*, *k*) by the transverse convexity of its surface. The internal bounding ridge (figs. 2, 3 *f'*) is sharp and high, but less so than in the Bear. The postero-external (figs. 1, 3, 0) is very thin and sharp, and slightly undercut. The olecranal fossa (fig. 1 *p*) is of great depth and size, especially on the external side, but the coronoid (fig. 3 *d*) fossa is hardly defined, the surface of the shaft passing in an easy sweep to the edge of the articulation. The whole

arrangement of the articulations of the humerus in Felis indicate the power of using the fore limb with great force in a great variety of directions.

§ 3. *Measurements.*—The variations in size of the humeri of *Felis spelæa, F. leo,* and *F. tigris* are shown in the following table:

TABLE OF MEASUREMENTS.

MEASUREMENTS OF HUMERUS.	*Felis spelæa.*											*Felis leo.*			*Felis tigris.*
		Taunton Museum.													
	Schmerling's figure. Belgium.	Bleadon Cave.	Bleadon Cave.	Bleadon Cave.	Bleadon Cave.	Bleadon Cave.	Sandford Hill Cave.	Oreston Cave.	Gailenreuth Cave. Sir P. Egerton. Cast, Bt. Mus.		(Winwood) Larkhall, near Bath.	W. A. S.	*Leo Barbarus*, 112 A.	112 K. Asiatic Lioness.	British Museum, 114 K.
Extreme length	13·75	...	...	...	...	...	...	...	...	...	...	13·0	13·3	11·2	11·50
Minimum circumference	...	...	5·50	...	...	...	...	...	...	...	...	4·10	4·4	3·9	3·90
Transverse measurement of proximal articulation	...	4·10	...	...	...	...	...	...	...	4·30	...	3·00	2·7	2·2	2·30
Vertical ditto	...	4·60	...	...	...	...	...	...	...	...	...	3·40	3·5	3·4	3·30
Transverse measurement of distal articulation	...	...	...	2·80	2·55	2·57	3·00	...	...	2·70	2·40	2·40	2·4	1·9	1·90
Vertical ditto	...	...	...	4·00	3·50	3·50	4·30	...	...	2·70	...	2·30	2·3	2·0	2·20
Depth at distal end of deltoid ridge.........	...	...	...	...	...	...	...	2·02	3·36	...	...	2·00	1·85	1·65	1·4
Transverse measurement at same point	...	...	...	...	...	...	...	1·15	1·40	...	...	1·20	1·14	0·95	0·92

CHAPTER XI.

Femur, Pl. XVIII, figs. 4, 5.

CONTENTS.

§ 1. *Introduction.*
§ 2. *Description.*
§ 3. *Measurements.*
§ 4. *Definition.*

§ 1. *Introduction.*—The femur of *Felis spelæa* very closely resembles that of the Lion and Tiger, and, so far as we can judge from the fragments, it bore the same proportion to the pelvis and tibia that it does in those two animals, being much longer than the tibia, a proportion that is reversed in the smaller felines. As we have met with no perfect spelæan femur in Britain, we have adopted the same artifice as in the humerus. We have used as the groundwork of our figure the cast of a perfect spelæan femur from Gailenreuth Cave, the original of which is in the collection of Sir Philip Egerton, F.R.S. It is drawn in a light tint. In a somewhat darker tint we have represented a large portion of the shaft of a British specimen, and in full tint a considerable portion of the head, which, equally with the above, exactly corresponds in size with the cast, and a distal end which is rather smaller, and in this way we have built up the bone from fragments found in Britain. A small portion of a still larger distal end and the entire distal end of a smaller specimen are with others in the Taunton Museum. They are all from Bleadon Cavern. Since the figure was drawn we have found a nearly perfect shaft in the Jermyn Street Museum, obtained from the brickearth of Hartlip, in Kent, and slightly smaller than the specimen from Gailenreuth. A very fine specimen also of the shaft, slightly smaller than the femur from Gailenreuth and that from Bleadon, which we figure, has been found in the gravels of Barnwell, a suburb of Cambridge, and is preserved in the British Museum.

§ 2. *Description.*—The head (fig. 4, *a a'*) of the bone is hemispherical, and larger than the neck, which it overhangs distally (fig. 4, *a*). On its postero-internal surface is a very shallow depression, much less strongly marked than in most animals, for the ligamentum teres. The neck connecting the head with the shaft is short and massive, and resembles

in form the frustrum of a compressed conoid, the proximal surface being horizontal, while the distal points diagonally upwards at an angle of forty-five degrees. The shaft is nearly straight, cylindrical, and slightly enlarged at the ends, and when compared with that of the Bear is far more massive. It gives the idea of immense strength combined with great lightness.

A stout ridge runs from the posterior edge of the head, parallel to the distal surface of the neck, to the smaller trochanter, or "trochantine" as it is termed by Straus-Durckheim, which is an oval process with its long axis parallel to the neck. To its smooth summit is attached the psoas muscle, the iliacus internus in the Cat being merely a second head of the latter. From the outer and lower base of the trochantine a sharp edge turns diagonally upwards, and forms the external edge of the great trochanter, and affords attachment to the quadratus. The trochanter is formed on the same plan as in Man, but is proportionally larger and higher; it is separated from the neck behind by the great trochanterian cavity in which the tendons of the obturator muscles are inserted. Its external summit is chamfered and hollowed for the attachment of the pyriformis; to its rounded outer summit (fig. 4, *b*) is attached the gluteus medius, and anteriorly to the massive tuberosity (fig. 4, *c*) the gluteus maximus.

The adductores longus and magnus are in the Feles extensor muscles of the thigh, and therefore require an attachment posterior to the lateral position they occupy in Man. Consequently the sharp ridge forming the outer lip of the linea aspera in Man is, as it were, removed to the extreme outer edge of the posterior surface of the bone, and the two above-named muscles, termed in their new position curvatus and arquatus by Straus-Durckheim, occupy the greater part of the posterior surface. The inner lip of the linea aspera is represented by a slightly roughened surface passing diagonally across the bone, and affords attachment in its upper part to the adductor brevis and the pectinæus.

The outer lip of the linea aspera is roughened and enlarged immediately below the lateral tuberosity of the great trochanter, so as to form a rudimentary third, which affords attachment to the gluteus maximus. Inferiorly it may be traced to the external angle of the outer tuberosity above the outer condyle.

This external position of the linea aspera causes the origin of the vastus externus to be entirely on the anterior and external surfaces, and it consequently occupies the whole of the upper part of this surface of the bone and the anterior edge of the linea, while the part corresponding internally is occupied by the vastus internus; between them are the origins of the crural proximally and the subcrural distally. The second head of the triceps cruris attached in Man to the outer lip of the linea aspera has no analogue in Felis.

The distal extremity of the femur differs remarkably from that of Man. The two condyles (fig. 5, *l l'*) are subequal, the internal (figs. 4, 5, *l*) being somewhat the larger, and reaching slightly further down. The intercondylian anterior articulation (figs. 4 5 *f*) for the patella is square in outline, and is defined by a high and well-marked ridge; it occupies

almost the median line of the shaft. The lateral surfaces of the process on which it stands are very nearly symmetrical (fig. 5, *g g'*), the external (fig. 5, *g*) forming a slightly more acute angle with the patellar articulation; the condyles extend further behind than in Man, and their lateral surfaces (figs. 4, 5, *l l'*) are roughened for the attachment of the lateral ligaments, and externally (figs. 4, 5, *l*) for the attachment of the extensor digitorum or cnemodactylus of Straus-Durckheim.

The condyles are separated by a very deep depression (fig. 5, *h*) for the crucial and other ligaments, passing slightly inwards, and rendering the inner condyle slightly smaller than the outer.

Immediately above the condyles the posterior surface of the shaft is flattened, and on its lateral edges are the internal and external tuberosities (fig. 4, *mn*), affording origin to the gastrocnemii muscles. In the angles between the condyles and the shaft are two small depressions (figs. 4, 5, *n*) for the lodgment of the sesamoid bones, called the external and internal crithoids, which, with a third below the external, are usually termed fabellæ. The two former are in the tendons of the gastrocnemii, and the latter in that of the popliteus.

The position of the nutritive artery varies, sometimes piercing the shaft in the middle of the lesser linea aspera, sometimes in the greater.

A fine specimen of the spelæan femur was discovered by Dr. Schmerling[1] in the caverns of Liége, and is figured in his great work. It agrees in every respect with the German and English specimens. The figure is produced by M. de Blainville[2] in his 'Ostéographie.'

§ 3. *Measurements.*—The following table shows the variations in the size presented by the femora of *F. spelæa*, *F. leo*, and *F. tigris*.

Table of Measurements of Femur in Felis spelæa, F. leo, and F. tigris.

Measurements of Femur.	*Felis spelæa.*							*F. leo.*			*F. tigris.*
	From Gailenreuth. Sir P. Egerton.	Taunton Museum.				Belgium. Schmerling's fig.	Barnwell Gravel. Brit. Mus.	W. A. S.	*Leo Barbarus.* 112 A, Brit. Mus.	Asiatic Lioness. 112 K, Brit. Mus.	*F. tigris.* 114 K, Brit. Mus.
		Bleadon.	Bleadon.	Bleadon.	Bleadon.						
1	16·65	...	...	...	...	16·60	...	14·40	14·5	12·4	14·2
2	5·00	...	...	...	4·80	...	4·2	3·90	4·2	3·4	3·3
3	3·00	3·10	...	...	...	...	...	2·50	3·0	2·3	2·0
4	3·00	3·10	...	...	...	...	...	2·50	3·0	2·3	2·3
5	3·20	...	3·20	3·00	...	3·40	...	3·00	2·8	2·6	2·5
6	6·30	...	5·80	6·00	...	...	...	4·60	4·8	4·5	4·3

[1] Oss. Foss. de Liége, tom. ii., Pl. xvi, fig. 2.

[2] Felis, Pl. xviii, fig. *b*.

§ 4. *Definition.*—On comparing the femora of the Cave Lion with those of other animals associated with it in Pleistocene deposits, the following points of difference may be enumerated. The straightness and cylindrical form of the shaft, and the symmetrical form of the distal end, distinguish it from that of the Cave Bear. In the Hyæna it is also symmetrical, but the great difference in size prevents the two being confounded together. In the latter animal, moreover, it is rather more bent and the patellar articulation is not so sharply defined. The large development of the third trochanter in the Horse is a point by which the most slender bone may be distinguished at a glance.

CHAPTER XII.

Tibia, Pl. XIX, figs. 1, 1′, 1″, 2, 2′. Fibula, Pl. XIX, figs. 3, 4. Patella, Pl. XIX, figs. 5, 5′.

CONTENTS.

§ 1. *Tibia.*
- α. *Description.*
- β. *Measurements.*
- γ. *Definition from other Pleistocene tibiæ.*

§ 2. *Fibula.*
- α. *Description.*
- β. *Measurements.*

§ 3. *Patella.*
- α. *Description.*
- β. *Measurements.*

§ 1. *Tibia* (Pl. XIX, figs. 1, 1′, 1,″ 2, 2′).—The tibiæ of all the digitigrade Carnivora are remarkably alike in general form, and offer constant differences characteristic only of genera or widely dissociated species. They present variations of proportion in animals of the same, as great in degree as in the closely allied but distinct species, such as Lion and Tiger, and are therefore of comparatively small value in classification. We have met with several specimens of this bone in the caverns of Somerset; the one (figs. 1, 1′) is perfect, with the exception of the proximal epiphysis, and belongs to a young animal; the other (figs. 2, 2′) consists of the proximal articulation of an adult; the former was obtained from Sandford Hill, the latter from Bleadon.

In the larger Feles generally the tibia is shorter, both proportionally to the femur and in relation to its own minimum circumference, than in the smaller forms. In Lion, Tiger, and *Felis spelæa,* it is considerably shorter than the femur; in the domestic and wild Cats, considerably longer. The articulations, as we have elsewhere remarked, are frequently larger in Tiger than in Lion, but the variations in this respect are so great that we agree with M. de Blainville in considering them of no specific value.

§ 1 α. *Description.*—The tibia of the larger Feles is a strong bone of slightly double curvature, bent gently forwards distally, and backwards proximally, cylindrical distally, but expanding into a prismatic form proximally; so that the proximal vertical diameter of the shaft is more than double the minimum near the distal end. The prism is so disposed that the narrowest side (fig. 1′ *b*) forms the posterior face of the bone, while the two broader meet in the strong anterior crest (figs. 1, 1′ *a*), which curves gently outwards and may be traced in the adult as far down as the distal end. The head (figs. 2, 2′ *c, d*) of the bone is partially occupied by the two slightly concave semilunar facets for articulation with the femur separated from each other by the small bifid eminence termed the

spine (figs. 2, 3′, *e*). They are deepened in the living animal by the semilunar cartilages that form an elastic or variable socket, and, with the adipose ligament in front, make up a broad articulation for the support of the hind quarters of the animal, which would otherwise rest on mere points. At the intersection of the nearly plain tibial facets and the highly convex femoral condyles, these cartilages are firmly fixed to both tibia and femur by strong ligaments. The facets are separated posteriorly by a deep notch (fig. 2′ *f*), in which is implanted the posterior crucial ligament, and are strengthened laterally by the external and internal tuberosities (fig. 2, *g*, *h*), affording attachment to the external and internal lateral ligaments. On the under side of the external tuberosity is a small oval articulation (fig. 2, *g*), for the head of the fibula, and under the posterior edges of the same tuberosity is a groove for the semi-membranosus muscle. In front of the spine, and forming a small shallow indentation in the anterior surface of the external facet, is a roughened space of triangular form (figs. 2, 2′, *l*) that extends inwards, so as to cut off the internal facet from the base of the crest. It affords attachment to the adipose cushion or ligament, filling the space between the tibia, the fore part of the distal articulation of the femur, and the patella. A strong and massive anterior tuberosity forms the antero-external boundary of the external facet (figs. 2, 2′, *m*). The proximal end of the crest is covered by a projecting and slightly roughened mass called the tubercle (figs. 2, 2′, *n*), which extends considerably downwards in the larger Feles, and in the two bones at Taunton of *Felis spelæa*, is nearly parallel to the posterior surface of the shaft. It affords attachment to the patellar tendon, which, through the medium of the patella, is the principal tendon of the muscles which act at once as the extensors of the tibia and flexors of the femur. Many of these muscles are also partially attached to the head and sides of the tibia, such as the rectus internus and sartorius, forming one muscle, the fascialis, the rectus anticus, vastus internus, and semi-tendinosus while others, viz., the arquatus, of Straus-Durckheim, the equivalent of the adductor magnus in Man, the popliteus and semi-membranosus and triceps cruris, act as the extensores cruris and flexores tibiæ, and leave their marks in the ridges and grooves on the posterior face of the bone. The posterior angles of the prismatic portion of the shaft are termed the extero- and intero-posterior crests (fig. 1′, *o*, *p*), the latter of which is traversed by a minute ridge, which is the line of attachment of the inter-osseous membrane that binds the tibia to the fibula. Near this and at a distance from the proximal end of about one third of the entire length, is the small foramen for the passage of the nutritive artery and nerve. The outward sweep of the crest (fig. 2, *m*) forms on the external surface a large concavity (fig. 2, *q*), affording origin to the large tibialis anticus, which acts as a flexor of the foot and extensor of the toes. A considerable portion of the length of the shaft is occupied by the origin of the flexor longus digitorum on the inner side, the tibialis posticus running in a parallel direction on the external surface close to the inter-osseous membrane.

The shaft increases in size as it approaches the distal articulation (figs. 1, 1″, *r*, *s*), which is of somewhat trapezoidal form, wider than deep in a vertical direction, divided

diagonally by a strong ridge into two concave depressions for the reception of the condyles of the astragalus. The inner of these is by far the deeper, because the internal malleolus (fig. 1, 1″, *r*) descends much further than the internal (figs. 1, 1″, *s*). The internal malleolus is rough and massive, and traversed posteriorly by a small groove (fig. 1″, *t*), running downwards and forwards, which is converted into a canal by an investing ligament, and receives the tendons of the tibialis posticus, and the flexor longus digitorum. The external edge of the outer facet (figs. 1, 1″, *s*) is rounded off to receive the small internal and lateral articulation of the fibula.

§ 1 β. *Measurements.*—The only difference to be found between the tibiæ of the *Felis spelæa* and the living Lion and Tiger is the massive proportions of the former. The specimen (fig. 1) is perfect, with the exception of the proximal epiphysis. Had the latter been present it would have been of nearly exactly the same length as that of the lion in our own possession, whereas the following table of measurements shows how much they differ in bulk. Other fragments in the Taunton Museum corroborate this evidence, and the most slender of the larger specimens is more massive than any leonine or tigrine bone which we have seen. Others, however, differ very little from the proportions of those in the two latter animals, and the whole form a graduated series without any break. In the large spelæan tibiæ the tuberosities are somewhat larger, and the tubercle for the patellar tendon passes further down on the crest, so as to form an attachment proportional to the massiveness of the limb.

Comparative Measurements.

	Felis spelæa.							*Felis leo.*			*F. tigris.*
	Taunton Museum.										
	Figured specimen. Sandford Hill Cave.	Figured specimen. Bleadon Cave.	Bleadon Cave.	Sandford Hill Cave.	Bleadon Cave.	Bleadon Cave.	Bleadon Cave.	W. A. S.	112 K, British Museum.	112, British Museum. Asiatic Lioness.	114 K, British Museum.
1. Maximum length	...	...	...	...	...	...	...	12·50	11·80	11·6	11·4
2. Minimum circumference	4·80	...	...	4·25	4·50	3·90	4·50	3·28	3·00	3·2	3·3
3. Transverse measurement of proximal articulation	...	3·60	3·20	...	...	...	...	3·00	2·70	2·9	2·9
4. Vertical ditto	...	2·80	2·60	...	...	...	...	2·20	1·80	1·6	1·6
5. Transverse measurement of distal articulation	3·00	...	...	...	...	...	...	2·30	2·08	1·9	1·9
6. Vertical ditto	1·90	...	...	...	...	...	...	1·30	1·21	1·2	1·2

PLATE VI.

Felis spelæa, Goldfuss.

(Skull: small form: lateral aspect.)

The skull belonged to Mr. Williams; the jaws to Mr. Beard.

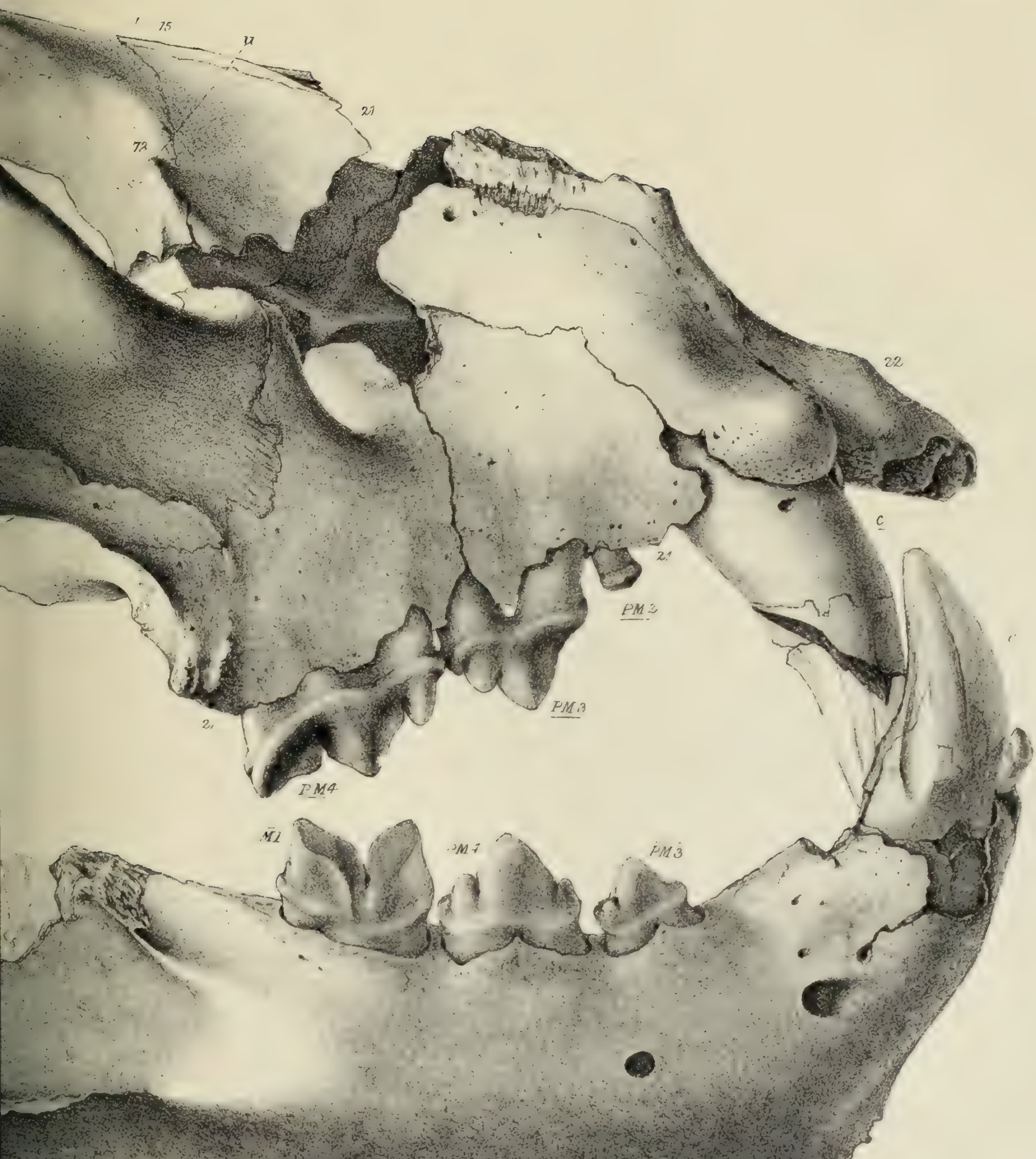
From either Sandford Hill or Hutton Caves in the Mendip. Now in the Taunton Museum.

W. Bidgood del et lith

FE

S

PLATE VI



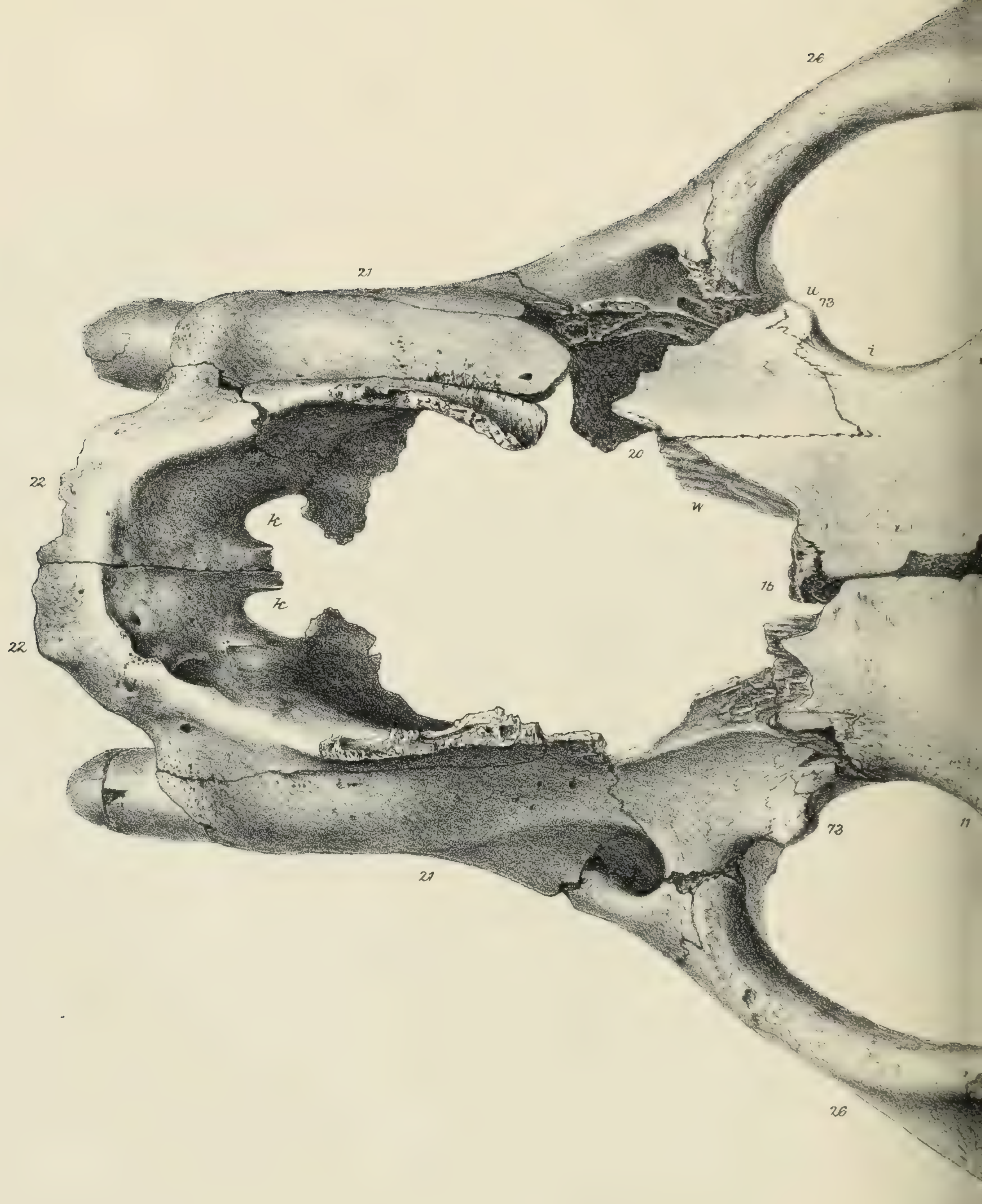
W West imp

PLATE VII.

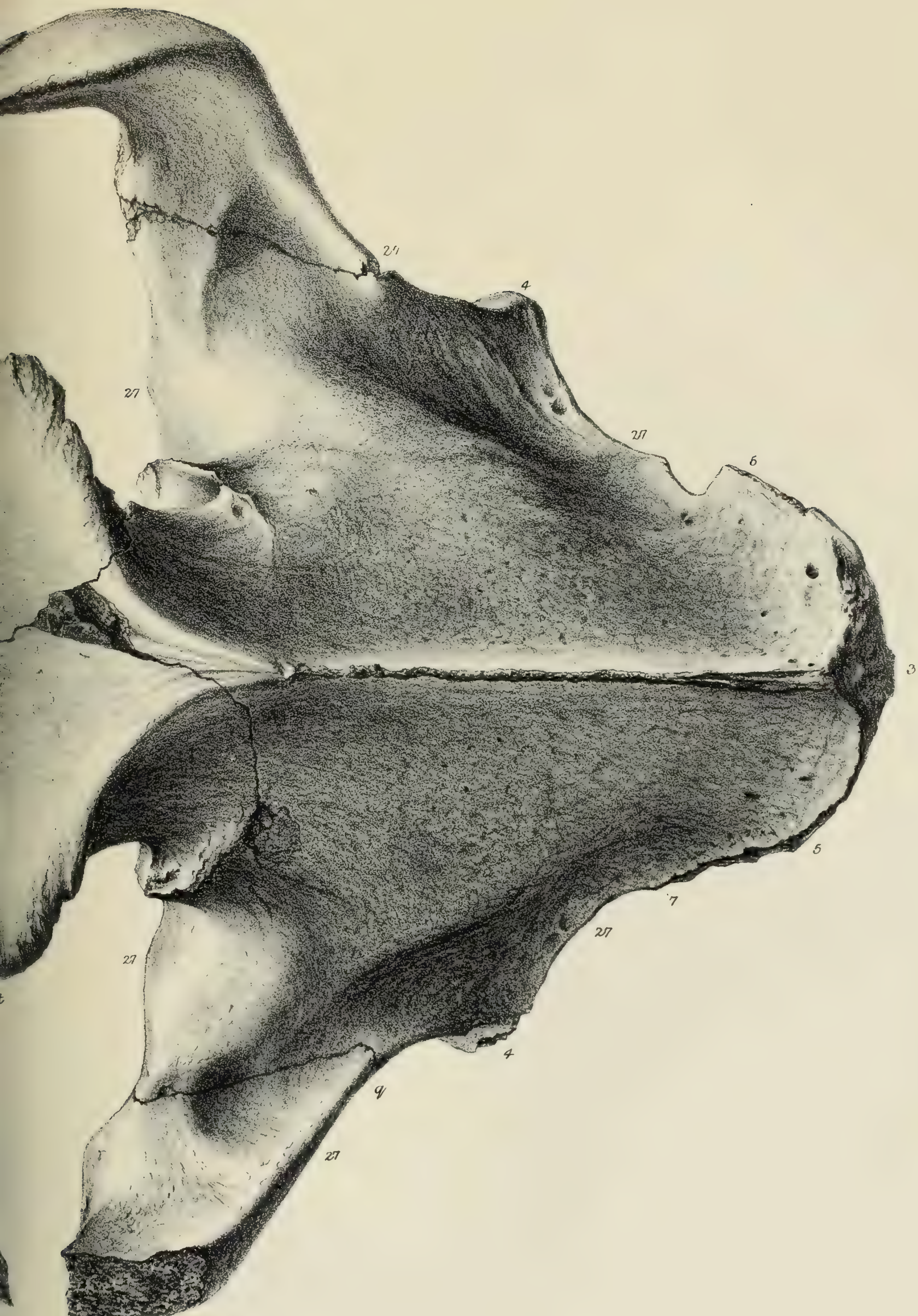
Felis spelæa, Goldfuss.

Skull : small form : natural size.)

Skull : the same as in Plate VI ; inferior or palatal aspect, showing the dentition.



W. Bidgood, del. et lith.



W. West imp

ULL. I.

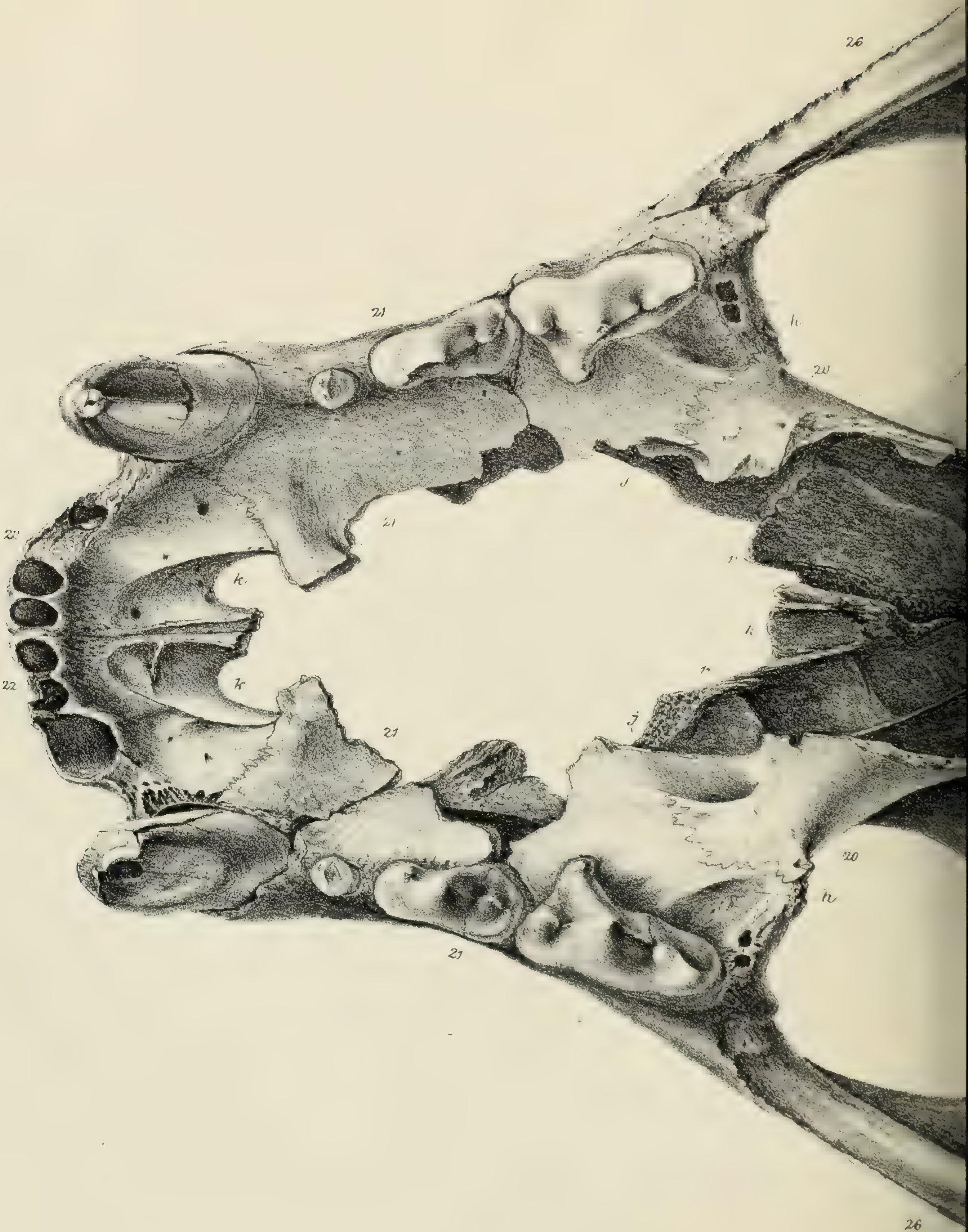
PLATE VIII.

Felis spelæa, Goldfuss.

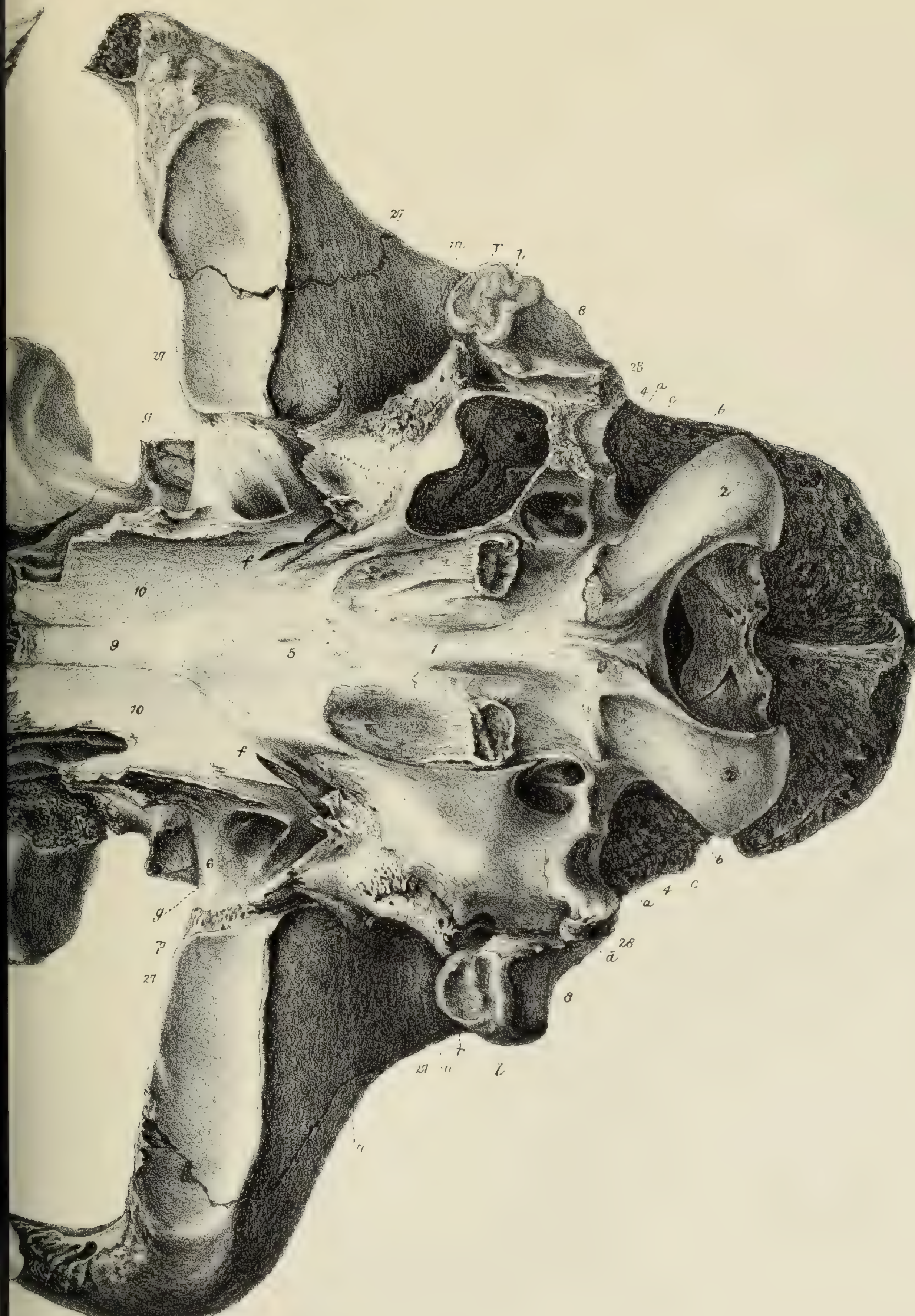
(Skull : small form : natural size.)

Skull : the same as in Plate VI ; upper or frontal aspect.

N.B.—The reference to Plate VIII, with regard to Dr. Spurrel's metatarsals, in page 22, must be transferred to Plate XXIII.



W. Bidgood del. et lith.



L L.

W West imp

PLATE IX.

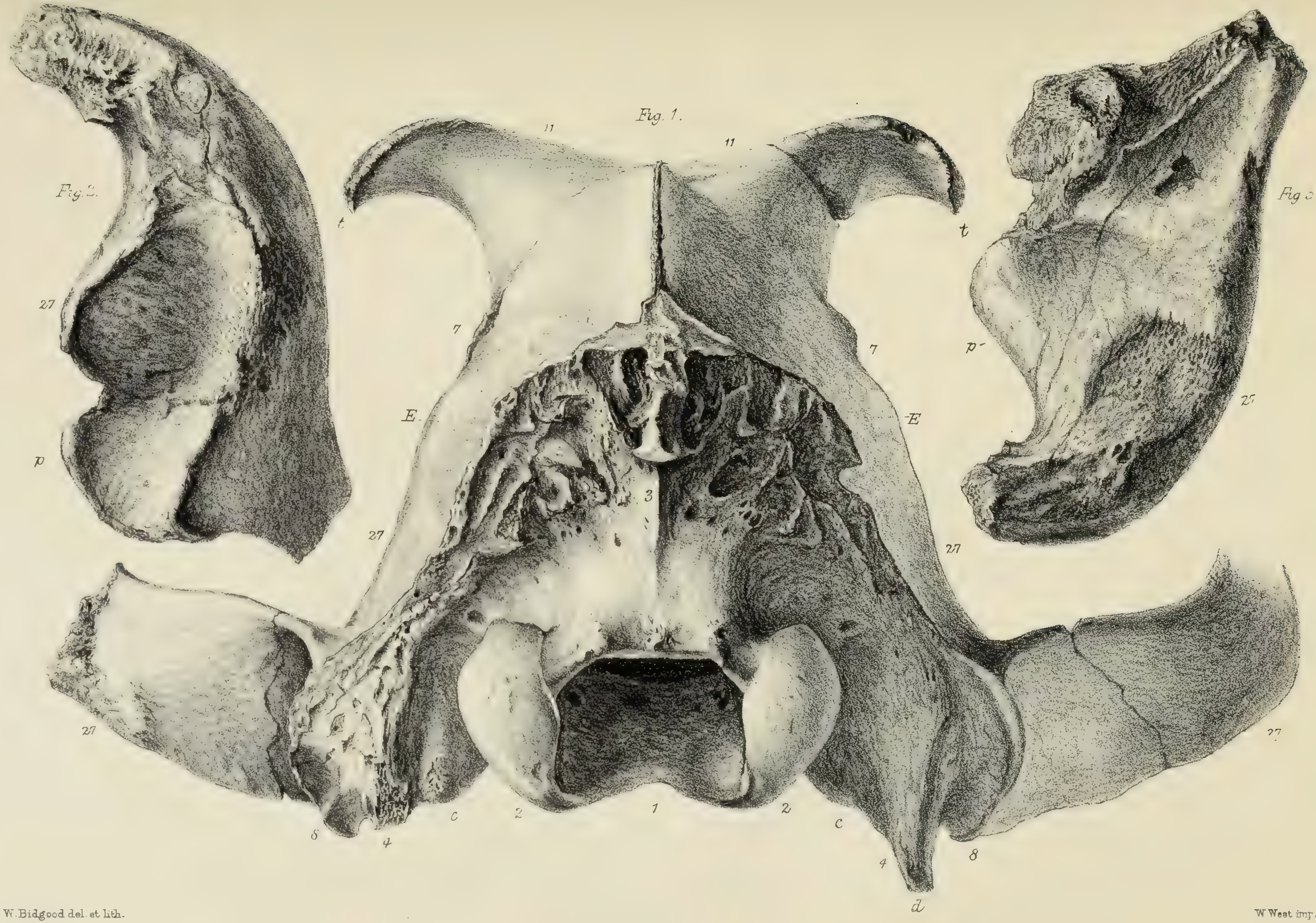
Felis spelæa, Goldfuss.

(Skull : small form : natural size.)

FIG.

1. Skull : the same as in Plate VI ; occipital or basal aspect.
2. Articular portion of the squamosal of a very large skull ; inferior or glenoid aspect. From Bleadon Cave. Mr. Beard's Collection, Taunton Museum.
3. Upper aspect of the same specimen.

FELIS SPELÆA. PLATE IX.



W. Bidgood del. et lith. W West imp.

SKULL.

PLATE X.

Felis spelæa, Goldfuss.

SKULL: LARGE FORM.

(Natural size.)

FIG.

1. Skull; upper or frontal aspect: large form. To this skull belong the lower jaws figured in Pl. I, unfortunately described by us in the first chapter as having been found in the Bleadon Cave. The whole were found together in Sandford Hill Cave by Mr. Beard, and are in the Taunton Museum.

2. Upper aspect of malleus from the above skull.

3. Lower aspect of malleus from the above skull.

W A Sanford del W Bidgood lith

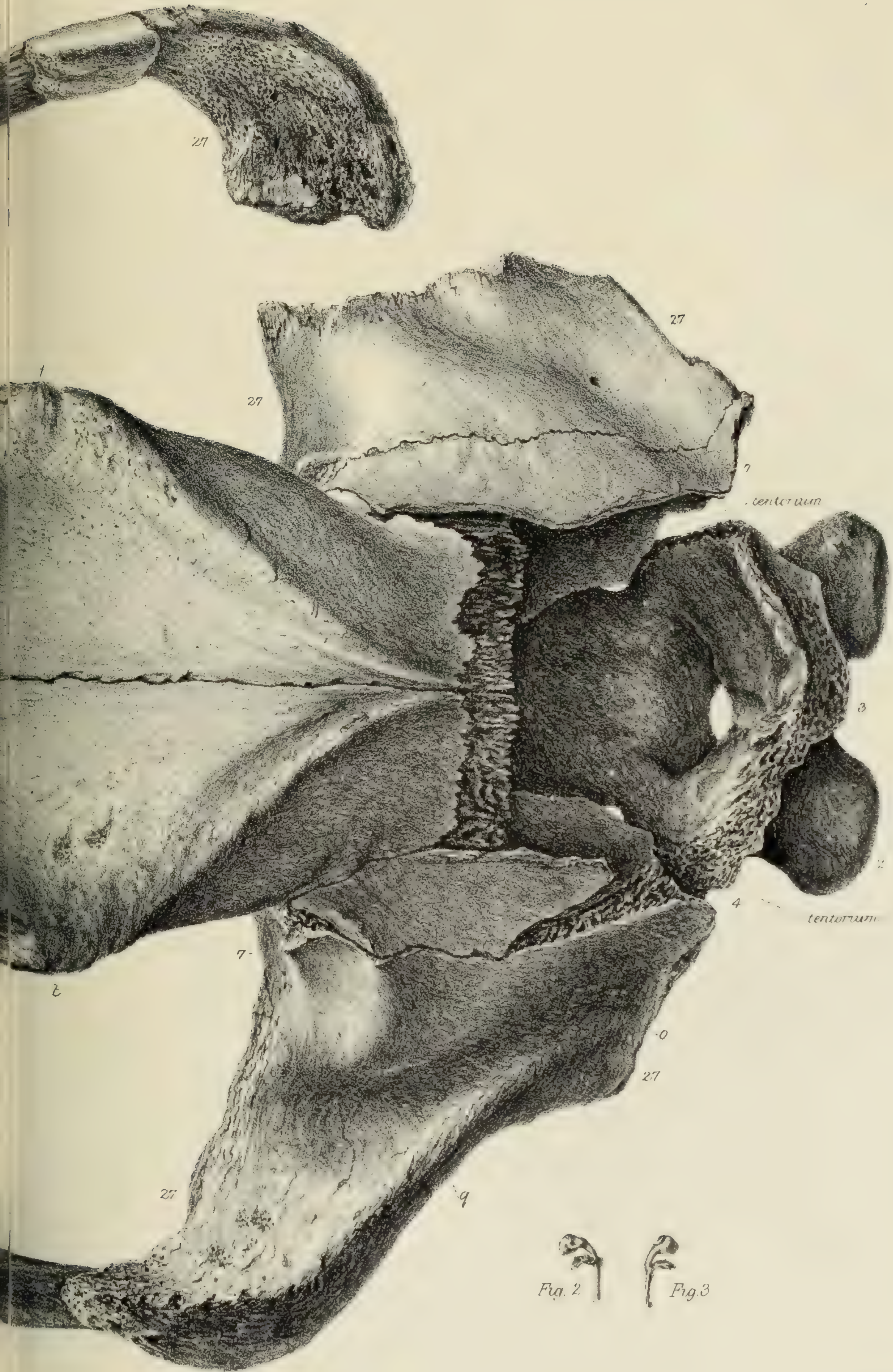

27
27
27
1
7
centorium
2
3
2
4
centorium
7
2
0
27
27
9
Fig. 2
Fig. 3

PLATE XI.

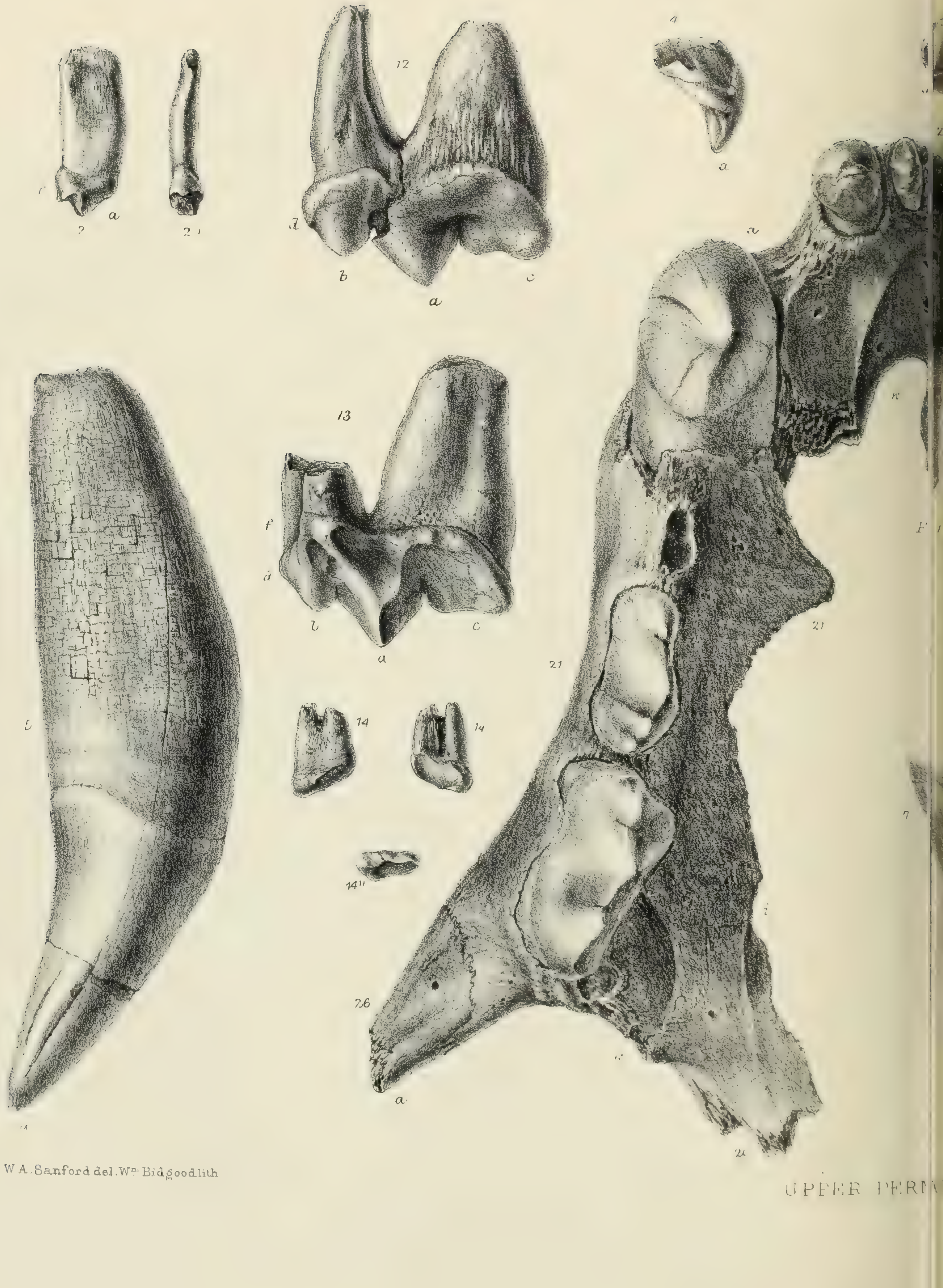
Felis spelæa, Goldfuss.

UPPER PERMANENT DENTITION.

(Natural size.)

Fig.	
1.	Maxillaries and intermaxillaries of very large animal, showing the whole of the dentition, except the first right incisor, the second premolars, and both true molars. The tips of the canines are slightly restored. From Sandford Hill Cave. Mr. Beard's Collection, Taunton Museum.
2, 2′.	First right incisor, outer lateral and posterior or palatal aspects.
3, 3′.	Second right incisor, inner lateral and posterior or palatal aspects. These two teeth are from Raven's Cliff Cave, Gower. Col. Wood's Collection.
4, 4′, 4″.	Third right incisor, outer lateral, coronal, and inner lateral aspects. Bleadon Cave, Mr. Beard's Collection, Taunton Museum.
5.	Right canine, outer lateral aspect, very perfect specimen of average size of large form. Raven's Cliff Cave, Gower. Col. Wood's Collection.
6.	Left canine, inner lateral aspect. Wookey Hyæna-den. Dr. Boyd: Taunton Museum.
7.	Right canine, outer lateral aspect. This belongs to the same animal as fig. 11. Williams's Collection, Taunton.
8, 8′.	Coronal and outer lateral aspects of left second premolar, large form. Bleadon Cave. Mr. Beard's Collection, Taunton Museum. The small form is shown in figures of skull in Pls. VI and VII.
9.	Third premolar, outer lateral aspect, right side, largest known to authors. Wookey Hyæna-den. In possession of Mr. Boyd Dawkins.
10.	Third left premolar, inner lateral aspect, average size of large form. Bleadon Cave. Mr. Beard's Collection, Taunton Museum.
11.	Third right premolar, inner lateral aspect, smallest known to authors. Probably from Bleadon. Mr. Williams's Collection, Taunton Museum.
12.	Fourth right premolar, outer lateral aspect, largest known to authors. Probably from Bleadon. Mr. Williams's Collection, Taunton Museum.
13.	Fourth left premolar, inner lateral aspect, average size of large form. Probably from Bleadon. Mr. Williams's Collection, Taunton Museum.
14, 14′, 14″.	Posterior or outer anterior or inner and coronal aspects of the true molar. Bleadon Cave. Mr. Beard's Collection, Taunton Museum.

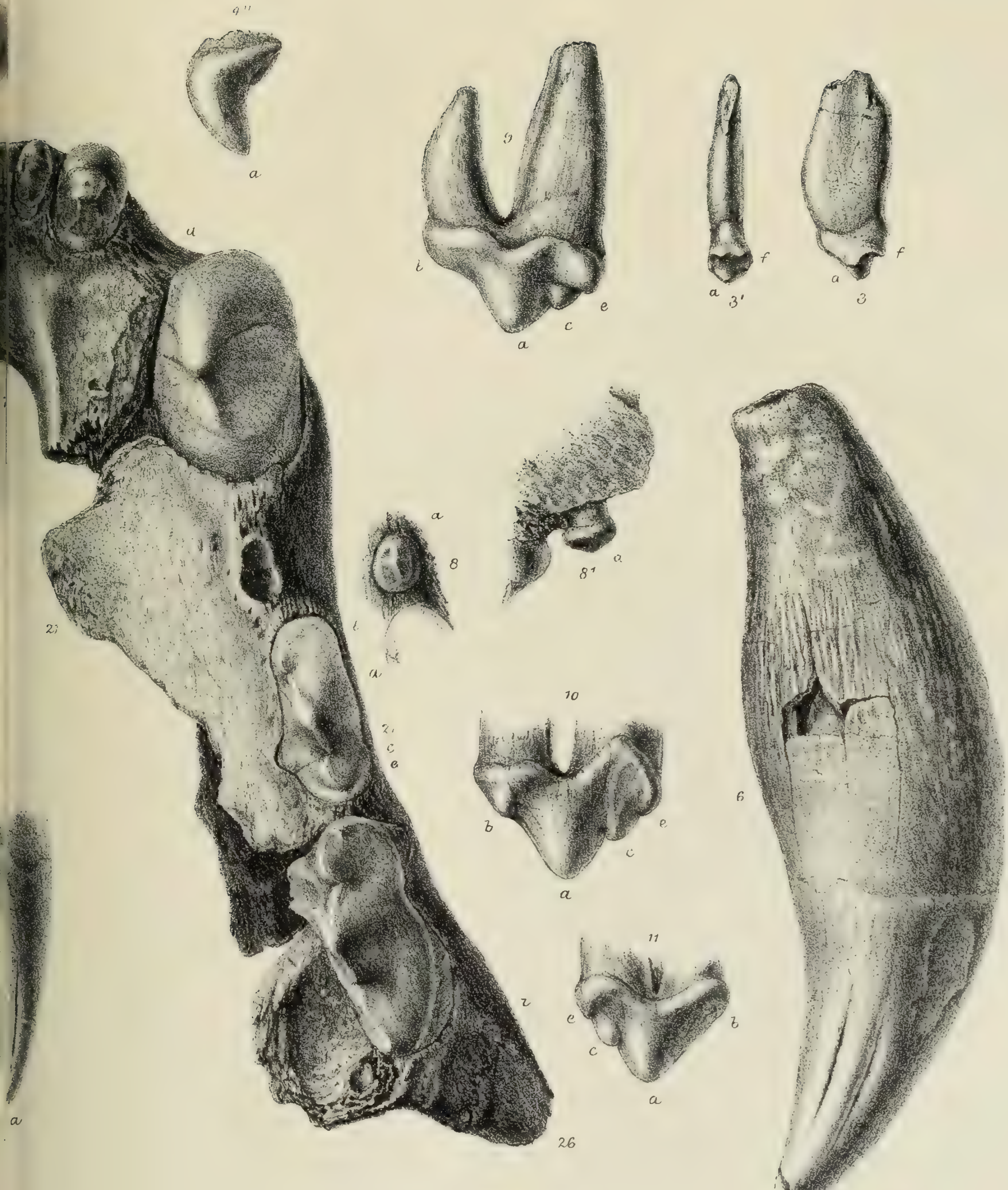
N.B. The small form of the fourth premolar is fully illustrated in the Pls. VI and VII of the smaller skull.



W A. Sanford del. Wm. Bidgood lith

UPPER PERM

PLATE XI



IT TEETH.

W West imp

PLATE XII.

Felis spelæa, Goldfuss.

LOWER PERMANENT DENTITION.

(Natural size.)

Fig.

1, 1′. First left incisor, anterior or outer and posterior or inner aspects.

2, 2′, 2″. Second left incisor, anterior or outer, posterior or inner, and inner lateral aspects.

3, 3′, 3″. Third left incisor, anterior or outer, posterior or inner, and outer lateral aspects. These three teeth are from Sandford Hill. No. 2 and 3 belong to mandible figured in Pl. I.

4. Right canine, outer lateral aspect: the largest known to the authors. Probably from Bleadon Cave. Mr. Williams's Collection, Taunton Museum.

5. Right canine, inner lateral aspect; rather small size of large form. Sandford Hill Cave. Mr. Beard's Collection, Taunton Museum.

6. Left canine, outer lateral aspect, of very old animal. Probably from Bleadon Cavern. Williams's Collection, Taunton Museum.

7. Third right premolar; largest known to the authors; outer lateral aspect. Bleadon Cave. Mr. Beard's Collection, Taunton Museum.

8, 8′. Third left premolar, inner lateral and coronal aspects, of the average size of large form. Bleadon Cave. Mr. Beard's Collection, Taunton Museum.

9. Third left premolar, inner lateral aspect: the smallest known to the authors. Wookey Hyæna-den. In possession of Mr. Boyd Dawkins.

10. Fourth right premolar, outer lateral aspect: the largest known to the authors. Bleadon Cave. Mr. Beard's Collection, Taunton Museum.

11, 11′. Fourth left premolar, inner lateral and coronal aspects: of the average size of large form. Probably from Bleadon Cave. Mr. Williams's Collection, Taunton Museum.

12. Fourth left premolar, inner lateral aspect: smallest known to the authors. Probably from Bleadon. Mr. Williams's Collection, Taunton Museum.

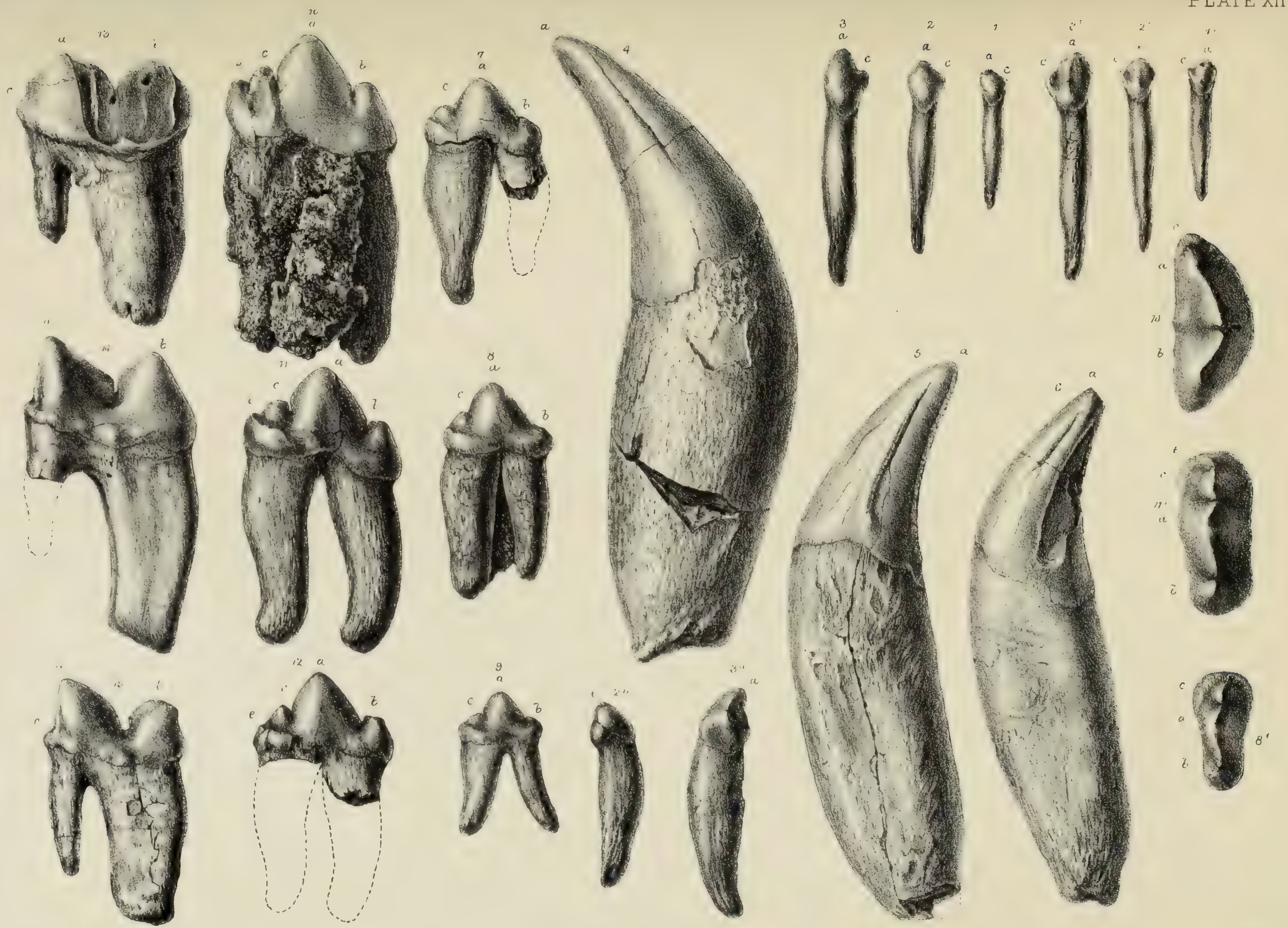
13. Right true molar much worn, outer lateral aspect: the largest known to the authors. Wookey Hyæna-den. In possession of Mr. Boyd Dawkins.

14, 14′. Left molar, of the average size of large form, inner lateral and coronal aspects. Probably from Bleadon. Mr. Williams's Collection, Taunton Museum.

15. Left molar, inner lateral aspect: smallest known to the authors. Wookey Hyæna-den. In possession of Mr. Sanford.

FELIS SPELÆA.

PLATE XII



W A Sanford del. Wm Bingo lith.

LOWER PERMANENT TEETH

PLATE XIII.

Felis spelæa, Goldfuss.

MILK DENTITION.

(Natural size.)

FIG.

1, 1′, 1″. Outer, inner, and inferior aspects of left maxillary. The small premolar 2 inserted in fig. 1″ is from that figured in fig. 2. Hutton Cave.

2, 2′. Outer and inner aspects of anterior portion of left maxillary. Bleadon Cave.

3, 3′. Outer and posterior aspects of right lower jaw, the crown of the canine and the incisor copied from other specimens, the lines of restoration being shown in the canine, and by the junction of the incisor with the jaw. Hutton Cave.

4. Inner aspect of part of right ramus of young individual. From Sandford Hill Cave.

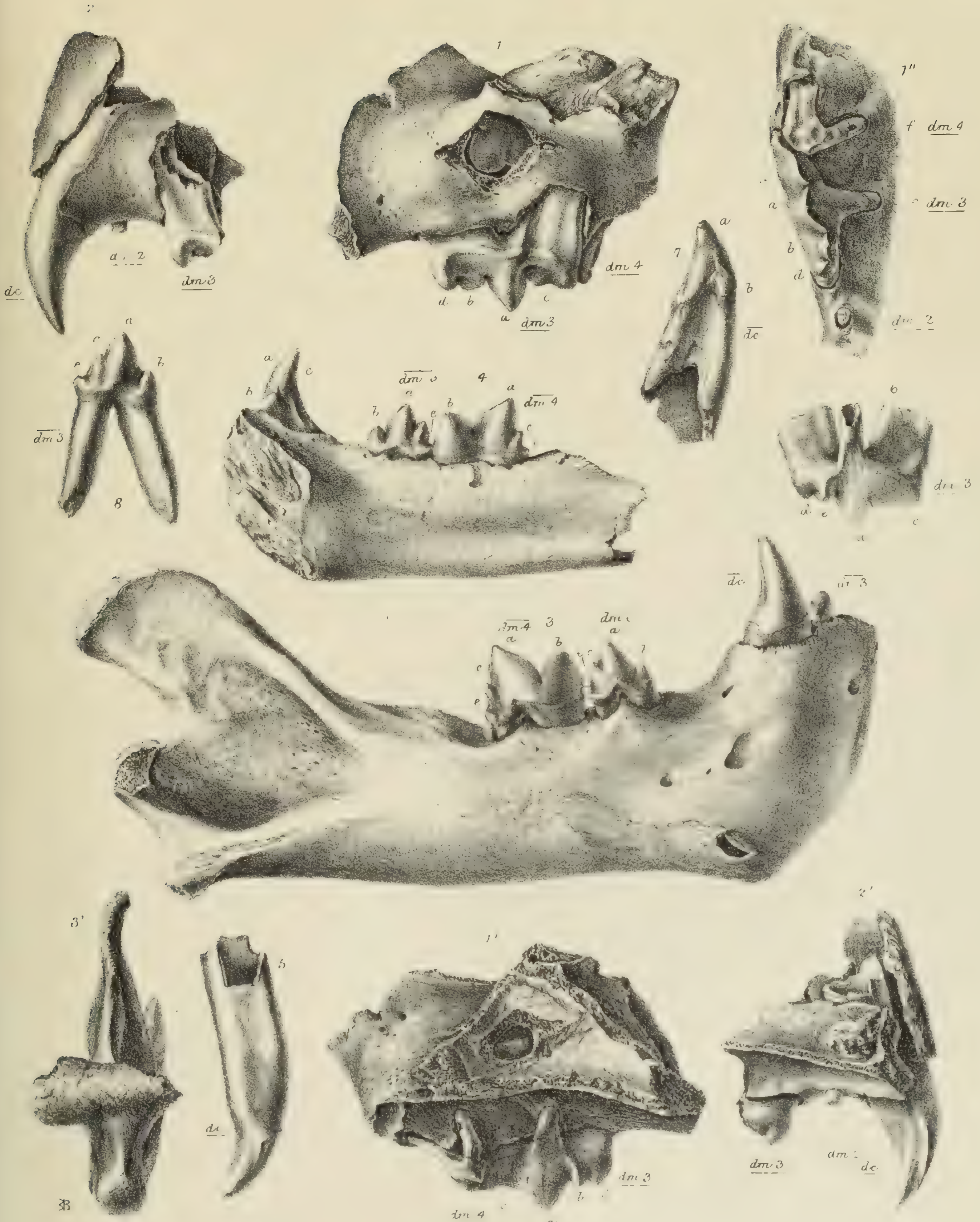
5. Upper canine, inner aspect. Probably from Sandford Hill Cave.

6. Upper milk molar 3, inner aspect. Sandford Hill Cave.

7. Lower canine, inner aspect. Probably from Sandford Hill. This tooth furnished the restoration for that in fig. 3.

8. Lower milk molar 3, inner aspect, of large size. Bleadon Cave.

All the above are in the Taunton Museum, and were found by Messrs. Beard and Williams in the caverns of the Mendip Hills.



W. A. Sanford del. W. Bidgood lith. W West imp.

MILK DENTITION

PLATE XIV.

Felis spelæa, Goldfuss.

VERTEBRÆ.

(Natural size.)

Fig.

1, 1′, 1″. Proximal, dorsal, and distal aspects of atlas. Sandford Hill Cave. The restoration of the transverse process is slightly enlarged from the cast of a specimen from Gailenreuth, in the possession of Sir Philip Egerton. It is to be seen in the British Museum and the Museum of the College of the Surgeons.

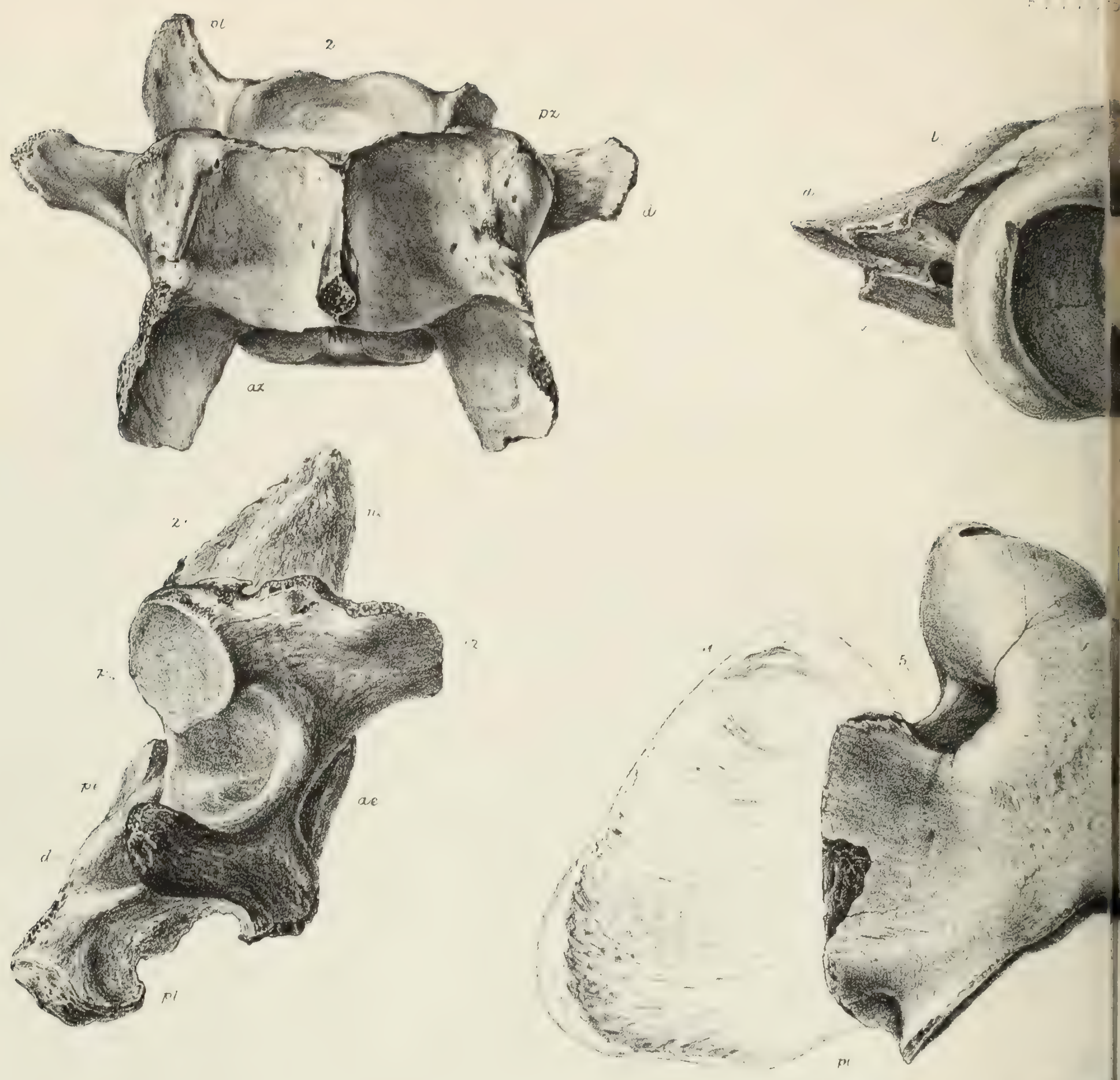
2, 2′, 2″, 2‴. Dorsal, lateral, proximal, and distal aspects of sixth cervical vertebra. Sandford Hill Cave.

3, 3′, 3″, 3‴. Proximal, dorsal, lateral, and distal aspects of seventh caudal vertebra. Bleadon Cave. All these specimens were found by Mr. Beard, and are now in the Taunton Museum.

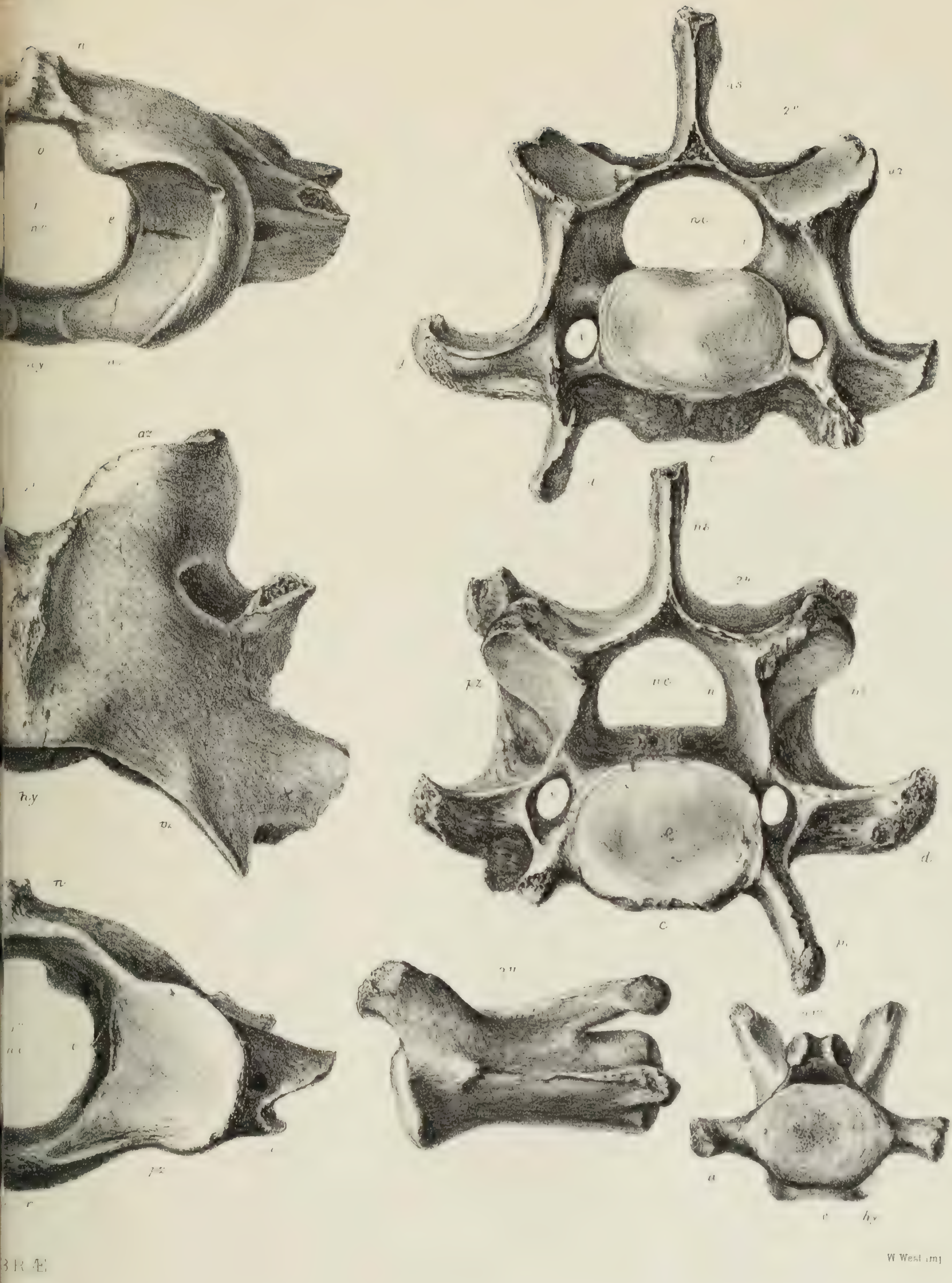
The following letters are used for the different parts of the vertebræ in Pls. XIV, XV, XVI:

c, centrum.
ae, anterior epiphysis.
pe, posterior epiphysis.
n, neurapophysis.
ns, neural spine.
pa, parapophysis.
pl, pleurapophysis.
hy, hypapophysis.

d, diapophysis.
a, anapophysis.
m, metapophysis.
az, pre-zygapophysis.
pz, post-zygapophysis.
nc, neural canal.
v, canal for vertebral artery.



W. A. Sanford del. W. West imp.



BRÆ

W West imp

PLATE XV.

Felis spelæa, Goldfuss.

VERTEBRÆ.

(Natural size.)

Fig.

1, 1′, 1″. Proximal, lateral, and distal aspects of a perfect second dorsal vertebra. Sandford Hill Cave. Mr. Beard's Collection, Taunton Museum.

W. A Sanford del J Dinkel lith

SECOND DORSAL VERTEBRA.

W West imp

PLATE XVI.

Felis spelæa, Goldfuss.

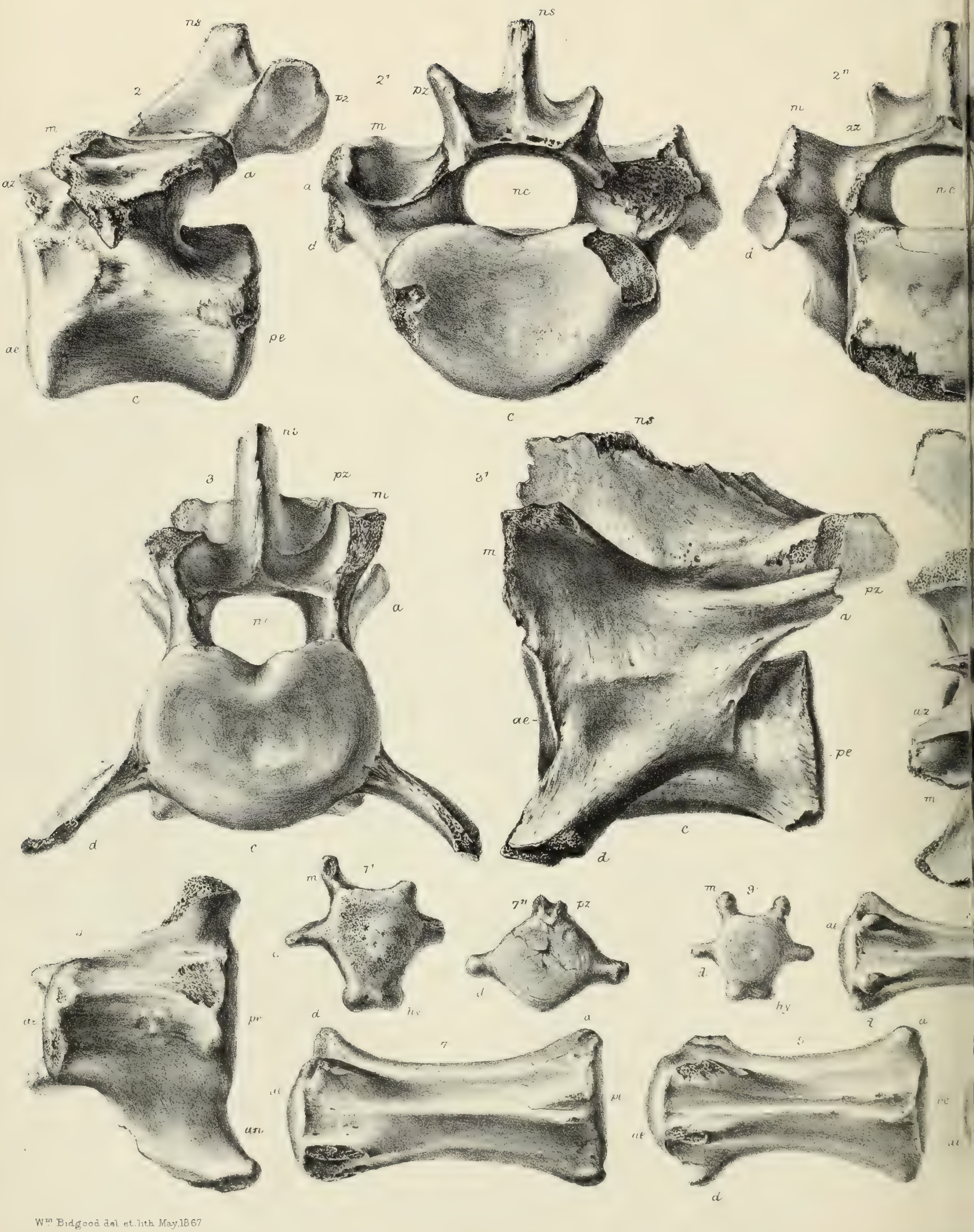
VERTEBRÆ; STERNUM.

(Natural size.)

Fig.	
1, 1′.	Seventh dorsal vertebra, distal and lateral aspects.
2, 2′, 2″, 2‴.	Eleventh dorsal; lateral, distal, proximal, and dorsal aspects.
3, 3′, 3″, 3‴.	Second lumbar vertebra, proximal, lateral, dorsal, and distal aspects.
4, 4′.	Fourth caudal vertebra, ventral and distal aspects.
5.	Ninth caudal vertebra, dorsal aspect.
6.	Tenth caudal vertebra, ventral aspect.
7, 7′, 7″.	Eleventh caudal vertebra, dorsal, proximal, and distal aspects; very large specimen.
8.	Twelfth caudal vertebra, lateral aspect.
9, 9′, 9″.	Fourteenth caudal vertebra, dorsal, proximal, and distal aspects.
10, 10′.	Third sterneber, lateral and ventral or superior aspect.

The above are in the Taunton Museum, and were in Mr. Beard's Collection. All were derived from Bleadon Cave, except No. 3, which was from Sandford Hill.

Nos. 5, 6, 8, 9, and perhaps 4, have the appearance of having belonged to one animal.



Wm Bidgood del et lith May 1867

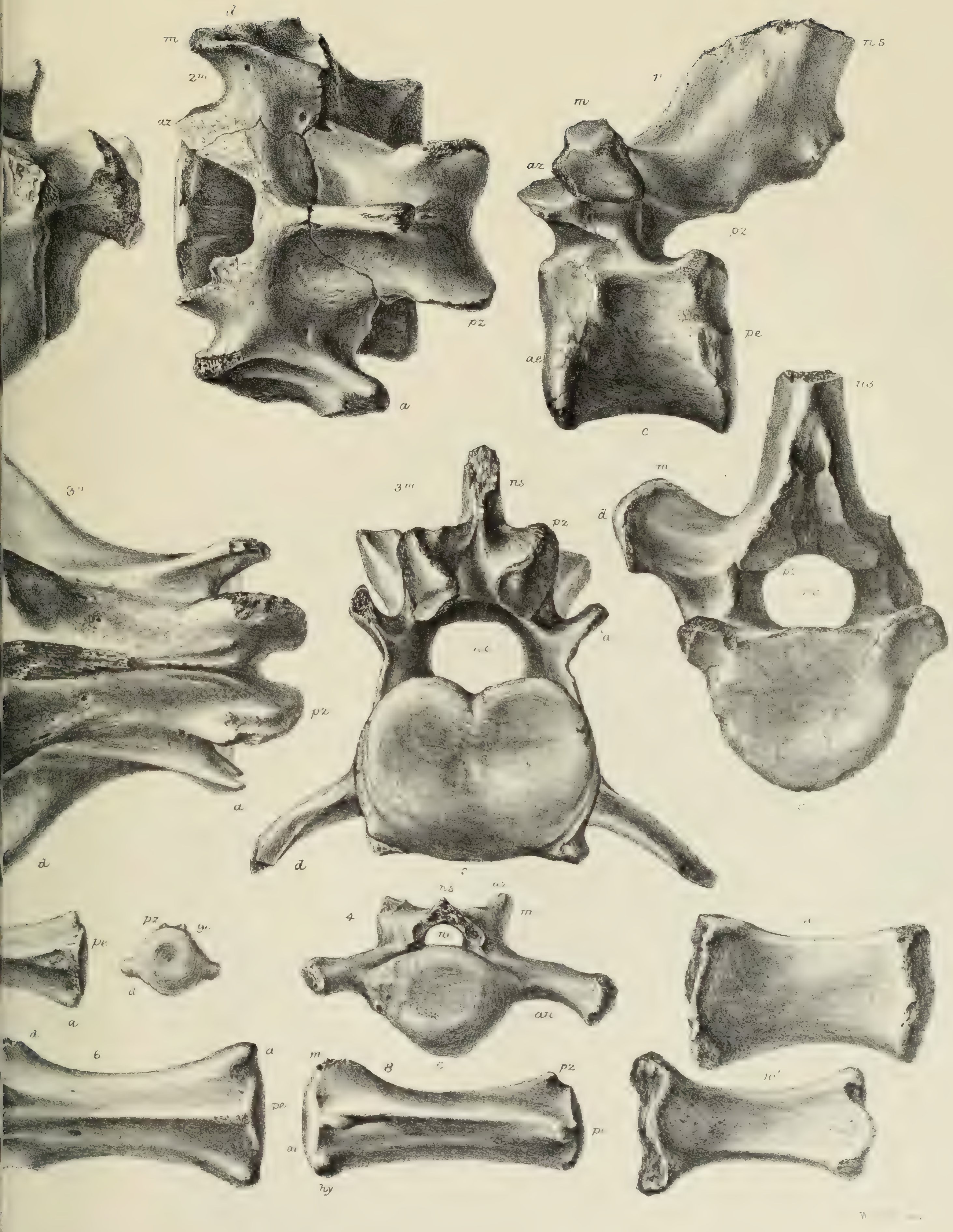

d
m
2'''
az
pz
a
ns
1'
m
az
oz
pe
ae
c
ns
3''
3'''
ns
pz
m
d
a
nc
pz
a
d
d
4
ns
az
m
pz
pe
d
a
an
c
d
6
a
pe
m
8
pz
pe
hy

PLATE XVII.

Felis spelæa, Goldfuss.

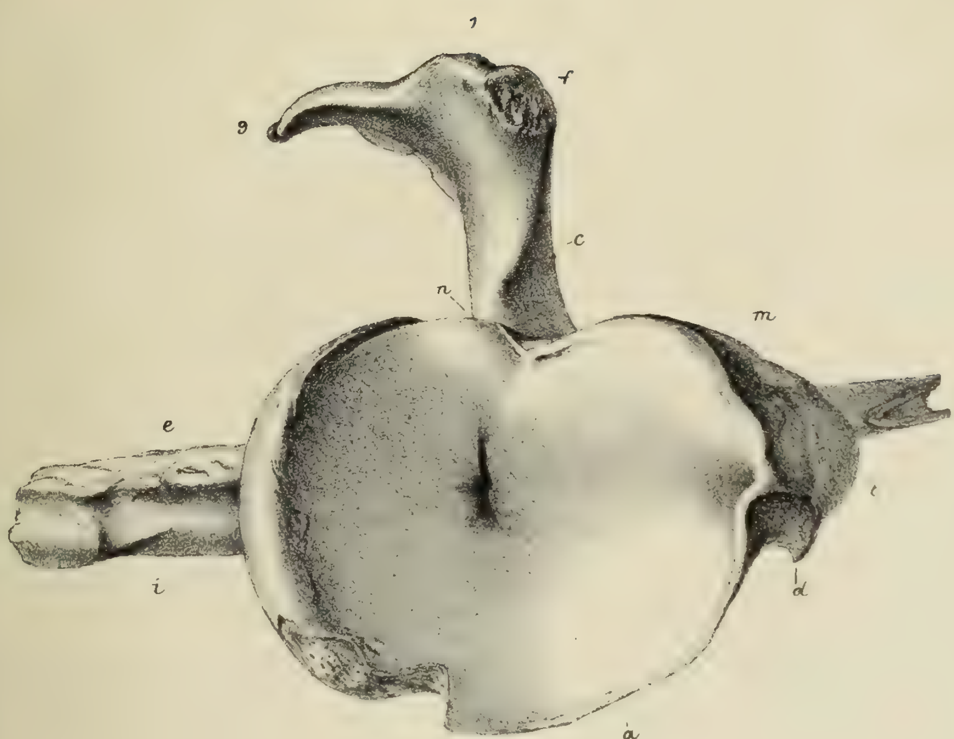
SCAPULA.

(Natural size.)

Fig.

1. Glenoid cavity and distal surfaces of the right scapula. From Sandford Hill Cave. Found by Mr. Beard; now in the Taunton Museum.
2. Outer or superior surface of the same bone.

W^m Bidgood del. et lith



W West imp

PLATE XVIII.

Felis spelæa, Goldfuss.

HUMERUS. FEMUR.

(Natural size.)

FIG.

1. Composite figure of the posterior or palmar aspect of the left humerus. The groundwork in pale tint is taken from Dr. Schmerling's great work on the caverns of Liège ('Oss. Foss. de Liège,' vol. ii, pl. xv, fig. 2). The distal end is from a humerus found in Bleadon. The small compressed shaft was found in Oreston, and is now preserved in the Bristol Museum. The imperfect proximal and distal articular portions are from Bleadon Cave. All the specimens from this latter cave are in the Taunton Museum.
2. Anterior aspect of distal end of left humerus, obtained by the Rev. H. H. Winwood, F.G.S., from the gravel of Larkhall, near Bath.
3. Distal articulation of very large humerus, left side. Sandford Hill Cave. Taunton Museum.
4. Composite figure of left femur. A cast of a specimen obtained by Sir Philip Egerton, from Gailenreuth Cave, supplied the groundwork in light tint. The proximal and distal ends and the fragment of shaft were obtained from Bleadon Cave by Mr. Beard, and are now preserved in the Taunton Museum.
5. Distal articulation of femur. Bleadon Cave. Taunton Museum.

HUMERUS FEMUR

PLATE XIX.

Felis spelæa, Goldfuss.

TIBIA. FIBULA. PATELLA. METACARPAL. METATARSAL.

(Half natural size.)

FIG.

1. Left tibia of young adult, anterior aspect; perfect, with the exception of the proximal articulation. Sandford Hill Cave. Taunton Museum.

1′. Proximal end of shaft.

1″. Distal articulation.

2. Anterior aspect of proximal end of left tibia. Sandford Hill Cave. Taunton Museum.

2′. Proximal articulation of the same bone.

3. Posterior aspect of right fibula, which probably belonged to the same animal as fig. 2. Sandford Hill Cave. Taunton Museum.

4. External aspect of distal end of left fibula. Bleadon Cave. Taunton Museum.

5. Anterior aspect of patella. Sandford Hill Cave. Taunton Museum.

5′. Posterior aspect of ditto.

(Natural size.)

6. Second left metacarpal of gigantic size. Lower Brickearths, Crayford. Dr. Spurrell's Collection.

7. Second left metatarsal of gigantic size. Lower Brickearths, Crayford. Dr. Spurrell's Collection.

These are referred to in p. 22 as figured in Pl. VIII.

FELIS SPELÆA: PLATE XIX

J Dinkel del et lith.

W West imp

BONES OF LIMBS.